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**Work Plan**  
**for**  
**Waste Oil Tank No. 10 and**  
**Building 325 No. 2 Fuel Oil Tanks**  
**for**  
**Naval Submarine Base**  
**New London**  
**Groton, Connecticut**



**Northern Division**  
**Naval Facilities Engineering Command**  
**Contract Number N62472-90-D-1298**  
**Contract Task Order 0129**

**October 1994**



STATE OF CONNECTICUT  
DEPARTMENT OF ENVIRONMENTAL PROTECTION



IX-26-94

Tim Evans  
Halliburton NUS Corporation  
993 Old Eagle School Road, Suite 415  
Wayne, Pennsylvania 19087-1710

Mr. Evans:

This office has reviewed the Work Plan for Waste Oil Tank No. 10 and Building 325 No. 2 Fuel Oil (August 1994) and the Site Characterization Report for Waste Oil Tank #5, both for the Naval Submarine Base, Groton, CT.

Both the work plan and the characterization report appear satisfactory, provided flame ionization detectors are used instead of photoionization detectors. FIDs are more sensitive to semi-volatiles and should be used consistently throughout the investigation and remediation project.

Signed,

A handwritten signature in dark ink, appearing to read "G. Scott Deshefy".

G. Scott Deshefy  
Supervisory Environmental Analyst  
UST Enforcement Program



661 ANDERSEN DRIVE • PITTSBURGH, PENNSYLVANIA 15220-2745 (412) 921-7090

C-49-09-4-366

October 6, 1994

Halliburton NUS Project No. 9594

Commanding Officer, Northern Division  
Naval Facilities Engineering Command  
10 Industrial Highway  
Mail Stop #82  
Lester, Pennsylvania 19113-2090

Attention: Mr. Brian Helland

Reference: CLEAN Contract N62472-90-D-1298  
Contract Task Order No. 0129  
Cost Impact Letter No. 6

Subject: Draft Work Plan for Waste Oil Tank 10 and  
Building 325 No. 2 Fuel Oil Tanks  
Naval Submarine Base - New London, Groton, Connecticut

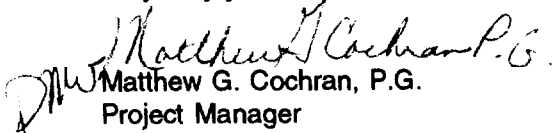
Dear Mr. Helland:

Enclosed are six (6) copies of the final draft of the subject document. Three (3) copies have been sent to Bob Brown at the Naval Submarine Base - New London, and four (4) copies have been sent to Scott Deshesy at the Connecticut Department of Environmental Protection.

The document has been revised based on your review letter dated September 13, 1994, addressing the addition of two monitoring wells downgradient of the oil/water separator. Revisions were also made based on the telephone conversation between Mr. Deshesy and Tim Evans (Halliburton NUS) on September 23, 1994, addressing the use of a FID instead of a PID monitoring device.

If you have any question concerning this document, please contact me at (412) 921-8418.

Very truly yours,

Matthew G. Cochran, P.G.  
Project Manager

MGC/tak  
Enclosures

cc: Mr. Roger Boucher, NORTHDIV (Letter Only)  
Mr. Bob Brown, Naval Submarine Base - New London  
Mr. Scott Deshesy, Connecticut Department of Environmental Protection, Hartford  
Mr. John Trepanowski, Halliburton NUS, Wayne (Letter Only)  
Ms. Debra Wroblewski, Halliburton NUS, Pittsburgh (Letter Only)  
File: CTO 0129

**WORK PLAN  
FOR WASTE OIL TANK NO. 10  
AND  
BUILDING 325 NO. 2 FUEL OIL TANKS  
FOR  
NAVAL SUBMARINE BASE - NEW LONDON  
GROTON, CONNECTICUT**

**COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY  
(CLEAN) CONTRACT**

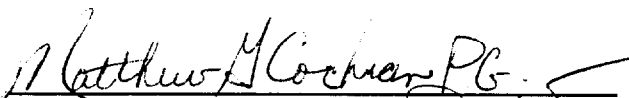
**Submitted to:  
Northern Division  
Environmental Branch, Code 1823  
Naval Facilities Engineering Command  
10 Industrial Highway, Mail Stop #82  
Lester, Pennsylvania 19113-2090**

**Submitted by:  
Halliburton NUS Corporation  
993 Old Eagle School Road, Suite 415  
Wayne, Pennsylvania 19087-1710**


**CONTRACT NUMBER N62472-90-D-1298  
CONTRACT TASK ORDER 0129**

**October 1994**

**PREPARED BY:**

  
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PROJECT MANAGER  
HALLIBURTON NUS CORPORATION  
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## **1.0 INTRODUCTION**

### **1.1 AUTHORIZATION**

The Northern Division of the Naval Facilities Engineering Command (NAVFAC) issued Contract Task Order (CTO) 0129 under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298 to Halliburton NUS Corporation (Halliburton NUS). The CTO is an assignment to perform remedial investigation activities at Subase-New London, located in Groton, Connecticut.

A Scope Change Letter dated April 11, 1994, and subsequent conversations with the Navy, directed Halliburton NUS to perform investigation activities at Waste Oil Tank 10 (OT-10), and an associated tank an oil/water separator, and also at two No. 2 fuel oil tanks adjacent to Building 325. Halliburton NUS responded to the Scope Change Letter by preparing a Cost Impact Letter dated May 3, 1994. The scope of work was negotiated on June 1, 1994 and a Confirmation of Negotiation Letter was submitted to the Navy on June 4, 1994.

This section is the introduction to the Work Plan which specifically addresses the additional field activities authorized as described above. Section 1 also includes a discussion of the scope and objectives in addition to a description and history of the tanks being investigated. Section 2 contains a detailed description of the required work tasks, and Section 3 provides the details of the field activities. Appendix A contains Halliburton Standard Operating Procedures (SOPs) and ASTM method descriptions. Appendix B contains field investigation forms.

All field activities described in this Work Plan will be conducted in accordance with the existing Quality Assurance Project Plan (QAPP) and Health and Safety Plan (HASP).

### **1.2 SCOPE AND OBJECTIVES**

The primary objective of this investigation is to collect the necessary data to determine the environmental impacts that the waste oil tanks at OT-10 and the fuel oil tanks at Building 325 may have had on the surrounding soil and groundwater. Following the data collection phase, remedial alternatives will be presented in the Site Investigation Report, if necessary. The two waste oil tanks and oil/water separator at OT-10 and one tank at B-325 will be kept in service; the other tank at B-325 is scheduled to be removed and permanently abandoned. Specific objectives of the project are as follows:

- To determine the magnitude and extent of petroleum-related contamination in soil or groundwater that may be present near the waste oil tanks at OT-10 and the two No. 2 fuel oil tanks at B-325.
- To establish a permanent leak detection system for the tanks remaining in service, including the OT-10 tanks and one of the No. 2 fuel oil tanks at B-325, concurrent with Federal regulations 40 CFR Part 280.

### 1.3 TANK DESCRIPTION AND SITE HISTORY

#### 1.3.1 OT-10

The tanks at OT-10 are located in the southern portion of Subase-New London, immediately north of Crystal Lake Road and between Sculpin Avenue and Tang Avenue and adjacent to Waste Oil Tank 5 (OT-05). The oil/water separator system which exists at OT-10 consists of a sump, a 30,000-gallon bilge water storage tank (registration number NN-03), an oil/water separator, and a 10,000-gallon waste oil tank (registration number NN-02). Oily bilge water is transported by truck to the site, discharged at a truck dumping pad to a sump, and then routed via an 8-inch line to tank NN-03 for holding. The bilge water is then pumped to the oil/water separator through a 1½-inch line. Waste water from the separator is sent by a 3-inch line to the sanitary sewer line on Tang Avenue and then to the sewage pumping plant located east of the Nautilus Museum and west of Military Highway. Waste oil from the separator is directed to tank NN-02. Construction details of NN-02 indicate this tank is made of fiberglass and was installed in 1981. The top of the tank is located approximately 4 feet below grade, and the bottom of the tank is approximately 12 feet below grade. Construction details of the larger tank (NN-03) could not be obtained, although it is reported that this tank is made of unlined steel and was installed in 1989.

In early 1993 the 30,000-gallon tank was pumped out, and the debris clogging the pumps was removed. The tank was then steam cleaned. The 10,000-gallon tank was also pumped out but could not be steam cleaned because groundwater continually filled the tank after being emptied. Site personnel report that the floor of the 10,000-gallon tank lacked a striker plate below the dipstick hole and had been punctured by the dipstick when the product level in the tank was being checked. A contractor subsequently patched the tank. No tightness test has been performed on this tank and the associated piping. It is unknown, but likely, that product escaped from tank NN-02. In addition, in September 1994, groundwater was noted to have infiltrated the oil/water separator. No releases have been reported from tank NN-03 or the oil/water separator. Groundwater monitoring systems for these tanks have not been installed.

In early 1994 Halliburton NUS performed field work in support of a Site Characterization Report (SCR) (Halliburton NUS, April 1994) for a nearby waste oil tank (OT-05). Waste Oil Tank 5 (OT-05) is a cylindrical reinforced concrete tank, approximately 112 feet in diameter and 11 feet deep. A concrete slab covers the tank and is supported by 37 concrete columns spaced 16 feet on center. The OT-05 tank capacity is approximately 750,000 gallons. The top of the tank is approximately 5 feet beneath the ground surface, and the base of the tank is approximately 17 feet beneath ground surface. Drilling results from Halliburton NUS' field operations indicate the soils underlying the site are composed of fine- to coarse- grained sand with some silt and gravel. The water table is approximately 4 feet below ground surface. The inferred groundwater flow direction is west-southwest directly towards the Thames River.

The tanks at OT-10 are approximately 480 feet southeast of the Spent Acid Storage and Disposal Area, which is located south of Buildings 409 and 410. The Spent Acid Storage and Disposal Area is being investigated as part of the Installation Restoration Program (IRP) Phase II Remedial Investigation (RI) at the Subase.

### **1.3.2     B-325**

Two No. 2 fuel oil tanks exist at B-325. One tank is located south of Building 325 and north of Triton Avenue in the Advanced Weapons Facility of Subase-New London. This tank (registration number R02) was installed in September 1991. It is constructed of unlined double-walled steel, coated with a coal tar epoxy-polyamide paint, and equipped with a low liquid level monitoring system. The tank is 21 feet long and 9 feet in diameter. The top of the tank is approximately 4 feet below grade, and the bottom of the tank is approximately 13 feet below grade. It is attached to a cement tie-down pad and has piping connections to Building 325. It has a capacity of 15,000 gallons and is the primary tank that supplies No. 2 fuel oil to the steam boiler in Building 325 for onsite heating. In December 1993 up to 26 inches of water were detected in the tank, suggesting a possible leak. The fuel oil and water were emptied from the tank, and the tank was placed temporarily out of service. In May 1994, the soil overlying the tank was removed to uncover the top of the tank, and a contractor entered and cleaned the tank. Upon visual inspection, the contractor found no structural faults with the tank. However, the fill and vent lines failed a tightness test. During the tightness test, air leaked from both the fill and vent lines, but water was also observed to be leaking from the vent line. The lines are expected to be replaced.

The other No. 2 fuel oil tank (registration number R01R1) at B-325 is located adjacent to and south of Building 325 in the Advanced Weapons Facility of Subase-New London. Construction details of tank R01R1 were not available except that it was installed in February 1989 and is constructed of steel. It has a concrete secondary containment, which is partially above ground surface, and the top of the tank is approximately

even with grade. The tank has a capacity of 10,000 gallons and is the secondary tank that supplies No. 2 fuel oil to the steam boiler in Building 325 for onsite heating.

An unknown quantity of fuel oil was reported to have been released from tank R01R1 in early 1993. The release was contained within its concrete secondary containment. Cracks have been noted in the concrete secondary containment, and it is unknown whether any fuel oil escaped. The tank is presently out of service, and all product has been removed from the tank. It is intended to be permanently removed and abandoned.

There is no evidence that either tank (R01R1 or R02) contained any material other than No. 2 fuel oil.

In March 1994 Halliburton NUS performed field work around Building 325 in the Advanced Weapons Facility of Subase-New London as part of the Installation Restoration Program (IRP) Phase II Remedial Investigation (RI). Results from the drilling activities of this field work identify the soils to be a fine- to coarse-grained gravel with trace silt and sand overlying a fine- to medium- grained sand with trace mica and silt. The depth to the bedrock surface varies from 3 feet to 32 feet below ground surface. The water table is approximately 3.5 feet below ground surface with the inferred groundwater flow direction to the west-southwest towards the Thames River.

Other monitoring wells and soil borings in the vicinity of this site indicate that soil and groundwater in this area have some contamination present, but no contamination from fuel by-products was detected.

## **2.0 WORK TASKS**

A total of three work tasks were identified in the Navy Scope Change Letter and are described in this section.

### **2.1 TASK 1 - WORK PLAN**

This task includes preparation of a draft and final version of a work plan, which is this document. The work plan includes detailed procedures for completing the scope of work and will be used as a reference document by Halliburton NUS and Navy personnel for completing the work activities.

### **2.2 TASK 2 - FIELD WORK**

The field work activities will consist of soil borings and monitoring well installations and soil and groundwater sampling. A detailed discussion of the necessary subtasks to complete the field work are included in Section 3 of this Work Plan.

### **2.3 TASK 3 - REPORT**

A preliminary draft, draft, and final report will be completed for this project that will summarize the results of the investigation. The report will include a site map showing the sample locations at each of the two sites, a cross-section figure for each site, and tables comparing contaminant concentrations to regulatory standards. No more than three remedial alternatives will be evaluated and recommendations will be made regarding the most cost effective alternative. It may be necessary to collect additional data in a second investigative phase if the intended objectives of the investigation are not met. If this is the case, then recommendations for additional work will be made instead of remedial alternatives, evaluations, and recommendations. An addendum to the report will be completed (if necessary) and include the results of the second investigative phase and remedial alternatives, evaluations, and recommendations. The report format will be as follows:

- Section 1 - Introduction
- Section 2 - Field Activities Methodology

- Section 3 - Investigation Results
- Section 4 - Remedial Alternatives and/or Recommendations For Additional Work

Additional material will be included as appendices (i.e., calculations, well logs).



## **3.0 FIELD ACTIVITIES**

### **3.1 FIELD ACTIVITIES SUMMARY**

A discussion of the field work activities is included in this section. Soil borings and monitoring wells with concurrent soil and subsequent groundwater sampling and analysis will be completed at OT-10 and B-325 to detect the lateral and vertical extent of any soil or groundwater contamination that may be present at these sites due to releases which may have occurred from underground storage tanks. Twelve subsurface soil samples from eight soil borings at OT-10 and eleven subsurface soil samples from seven soil borings at B-325 will be collected for laboratory analyses. All eight soil borings at OT-10 and four soil borings at B-325 will be converted to permanent groundwater monitoring wells with subsequent groundwater sampling at all permanent groundwater monitoring wells. In addition, one waste water sample and one waste oil sample from the 30,000 gallon tank (NN-03) at OT-10 will be collected for laboratory analysis to determine what contaminants are present in the waste material. Sampling and analysis with rationale is described in detail in the following sections and summarized in Table 3-1. The soil and groundwater sampling and analysis are designed to satisfy Federal regulations presented in 40 CFR, Part 280, including Subpart D (Release Detection), Subpart E (Release Reporting, Investigation and Confirmation), Subpart F (Release Response and Corrective Action for UST Systems Containing Petroleum or Hazardous Substances), and Subpart G (Out-of-Service UST Systems and Closure).

Halliburton NUS Standard Operating Procedures (SOPs) will be followed during field work activities and are referenced whenever possible regarding detailed procedures for a particular activity. All SOPs required for this field activity are included in Appendix A.

### **3.2 MOBILIZATION/DEMOBILIZATION**

Following approval of the Work Plan, Halliburton NUS will begin mobilization activities. All field team members will review the Work Plan. In addition, an addendum to the existing Health and Safety Plan (HASP) (Halliburton NUS, October 1994) for Subbase-New London, will be completed to specifically address the work activities to be conducted during this field work. A field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

The Field Operations Leader (FOL) will coordinate the mobilization activities. The FOL will also make any arrangements for equipment and supplies required to conduct the field investigation. The equipment

**TABLE 3-1**  
**ANALYTICAL PROGRAM - OT-10 AND B-325 SITES**  
**NSB-NLON, SUBASE-NEW LONDON, CONNECTICUT**

Media	Analysis	Analytical Method	Number of Samples <sup>(1)</sup>	Trip Blanks <sup>(2)</sup>	Equipment Rinsate <sup>(3)</sup>	Field Blank <sup>(4)</sup>	Duplicates <sup>(5)</sup>	Total Samples
<b>OT-10</b>								
Soil	TPH	E418.1	10	-	1	-	1	12
	BTEX	SW-846 8020	10	2	1	-	1	12
	TCL Volatiles	CLP SOW 0LM01.8	3	2	1	-	1	6
	TCL Semivolatiles	CLP SOW 0LM01.8	3	-	1	-	1	4
	TAL Metals	CLP SOW ILM02.1	3	-	1	-	1	4
	TCL Pesticides/PCBs	CLP SOW 0LM01.8	3	-	1	-	1	4
	Full TCLP	SW-846 1311 & 40 CFR 261	3	-	1	-	1	4
Groundwater	TPH	E418.1	5	-	1	-	1	4
	BTEX	SW-846 8020	5	1	1	2	1	8
	TCL Volatiles	CLP SOW 0LM01.8	4	1	1	2	1	8
	TCL Semivolatiles	CLP SOW 0LM01.8	4	-	1	2	1	7
	TAL Metals	CLP SOW ILM02.1	4	-	1	2	1	7
	TCL Pesticides/PCBs	CLP SOW 0LM01.8	4	-	1	2	1	7
Tank Contents	TPH	E418.1	2	-	1	-	-	3
	TCL Volatiles	SW-846 8020	2	1	1	-	-	4
	TCL Semivolatiles	CLP SOW 0LM01.8	2	-	1	-	-	3
	TAL Metals	CLP SOW ILM02.1	2	-	1	-	-	3
	TCL Pesticides/PCBs	CLP SOW 0LM01.8	2	-	1	-	-	3

**TABLE 3-1 (Continued)**  
**ANALYTICAL PROGRAM - OT-10 AND B-325 SITES**  
**NSB-NLON, SUBASE-NEW LONDON, CONNECTICUT**

Media	Analysis	Analytical Method	Number of Samples <sup>(1)</sup>	Trip Blanks <sup>(2)</sup>	Equipment Rinsate <sup>(3)</sup>	Field Blank <sup>(4)</sup>	Duplicates <sup>(5)</sup>	Total Samples
<b>B-325</b>								
Soil	TPH	E418.1	11	-	1	-	1	12
	BTEX	SW-846 8020	11	1	1	-	1	11
	Full TCLP	SW-846 1311 & 40 CFR 261	1	-	-	-	-	1
	TPH	E418.1	4	-	1	-	1	6
	BTEX	SW-S46 8020	4	1	1	-	1	7
Groundwater								

- <sup>(1)</sup> Number of samples includes 1 soil MS/MSD which will be collected with double volume, and 1 groundwater MS/MSD which will be collected with triple volume. MS/MSDs will be noted on each sample bottle, the COC, and the sample log sheets.
- <sup>(2)</sup> Trip Blanks: Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOC) samples. One trip blank per each cooler containing VOC compounds. Trip Blanks are only analyzed for VOCs.
- <sup>(3)</sup> Equipment Blank: Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis. Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed.
- <sup>(4)</sup> Field Blank: Samples consisting of the source water used in (1) steam cleaning and (2) decontamination. Obtained at a frequency of 1/event/source water.
- <sup>(5)</sup> Duplicates: A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

required for the field activities will be loaded in Pittsburgh, Pennsylvania, and sent to the site by the equipment manager. Much of the equipment is already on site in support of work activities currently being performed by Halliburton NUS in accordance with the original scope of this CTO. Therefore, mobilization activities will be minimal. The FOL will also coordinate with the Navy regarding clearing utilities prior to drilling activities.

### **3.3 SOIL BORINGS**

A total of eight soil borings at OT-10 and seven soil borings at B-325 will be drilled. The purpose of the soil borings is to characterize the subsurface lithology, install permanent groundwater monitoring wells, and establish a vertical profile of the subsurface contamination, if any. Proposed soil boring locations are shown on Figures 3-1 and 3-2. The soil borings will be drilled using minimum 6-inch inside diameter, hollow-stem auger techniques. Split-spoon samples shall be collected from each boring continuously at 2-foot intervals to the bottom of the borehole, in accordance with ASTM Method D1586-84 and Halliburton NUS SOP GH-1.3. The samplers shall have a minimum 3-inch outside diameter and be at least 2 feet in length in order to fulfill sample volume requirements for chemical analysis. The use of drilling fluids is prohibited while drilling. A lithologic description will be made of each split-spoon sample, and a complete log of each boring will be maintained by Halliburton NUS in accordance with SOP GH-1.5. At a minimum, the Halliburton NUS boring log will contain the following information:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color and moisture
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, depth to water, organic vapor monitor readings, drilling methods, and total depth of each boring will be included on each boring log.

### **3.4 SUBSURFACE SOIL SAMPLES**

Subsurface soil samples shall be collected continuously from each boring at 2-foot intervals to the bottom of the borehole, in accordance with ASTM Method D1586-84 and Halliburton NUS SOP GH-1.3. Split-spoon samplers shall have a minimum 3-inch outside diameter and at least be 2 feet in length in order to fulfill

MEMORANDUM

29 September 1994

From: Northern Division, Naval Facilities Engineering Command, B. Helland  
To: Halliburton NUS, M. Cochran

Subj: U.S. NAVY CONTRACT N62472-90-D-1298, CTO 129, CIL #6, INSTALLATION  
OF MONITORING WELLS, OT10 AND BLDG 325, NAVAL SUBMARINE BASE  
NEW LONDON

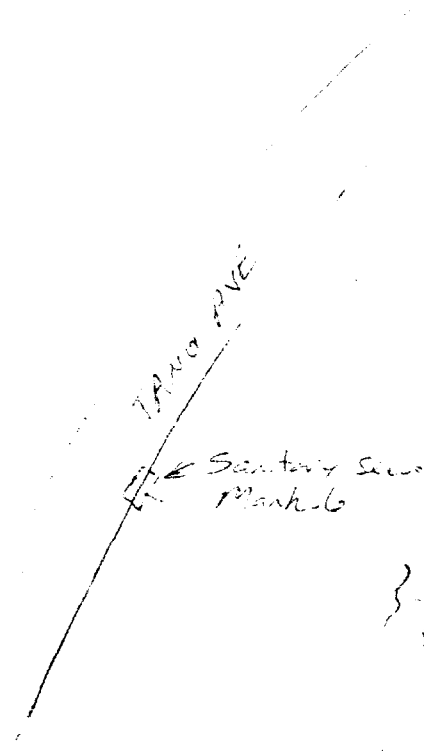
Encl: (1) Site plan of sanitary sewer line break at OT10

1. Enclosed is a site plan prepared by NSB New London showing the location of a break in the water discharge line from the oil/water separator at OT10. The line carried treated water from the separator to the sanitary sewer. The break has been repaired.

2. It is not believed that this break caused significant contamination, but Bob Brown suggested bringing it to your attention. Call me if you have any questions.

  
BRIAN J. HELLAND

Copy to: (w/c encl)  
NSB New London, R. Brown

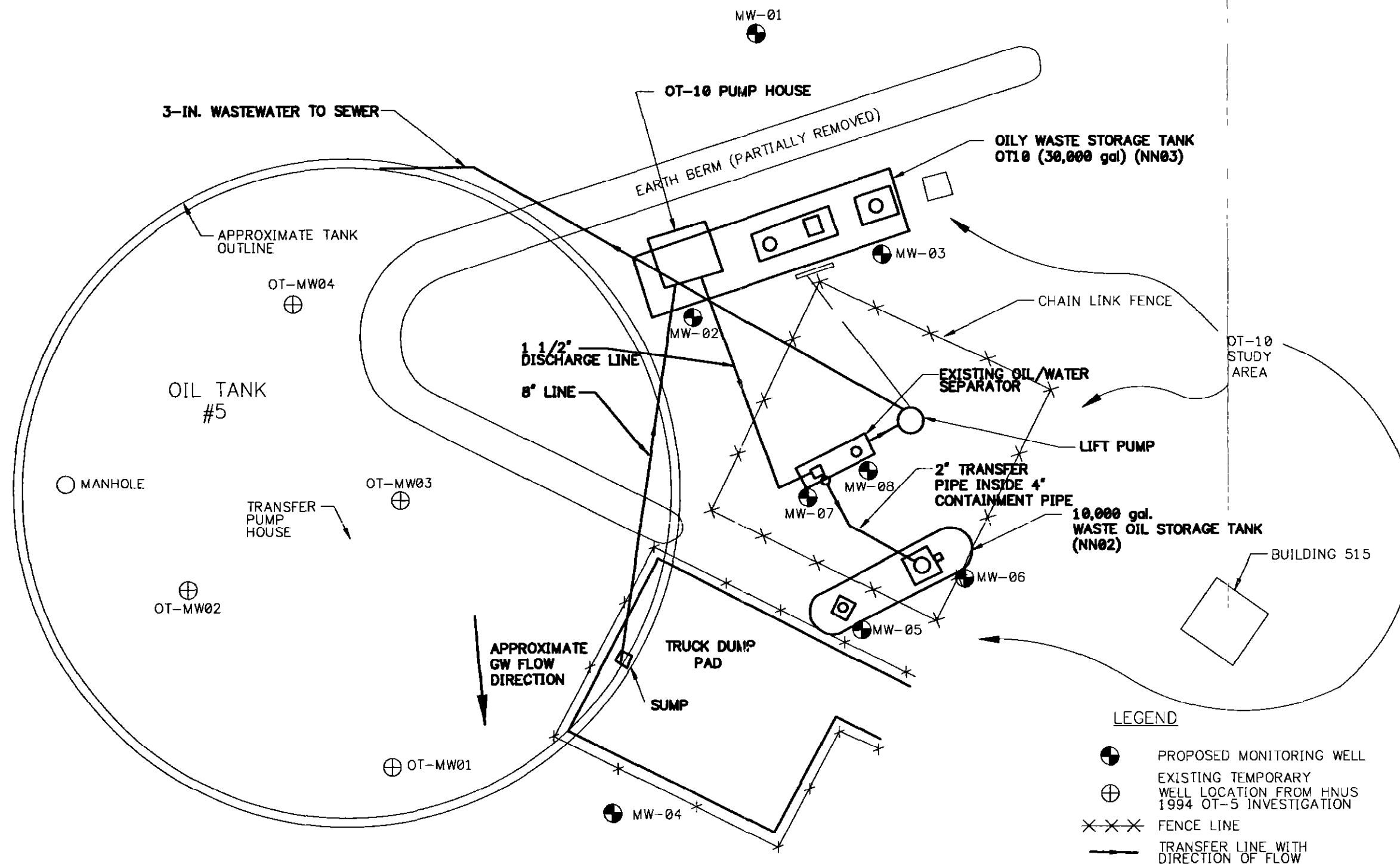
[illegible]

Bob,

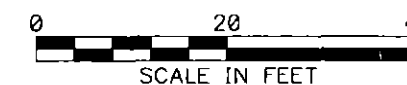
Shown is rough sketch of layout & orio indicating location of break in wastewater pipe transferring water to sewer after separation. Break in pipe causing sewer bypass reportedly occurred 10 Sept 9.

For purposes of assessing possible impact of bypass on two additional bearings to be placed at OT10 from seawater leak at 20 Aug 94, shall I contact Brian Holland?

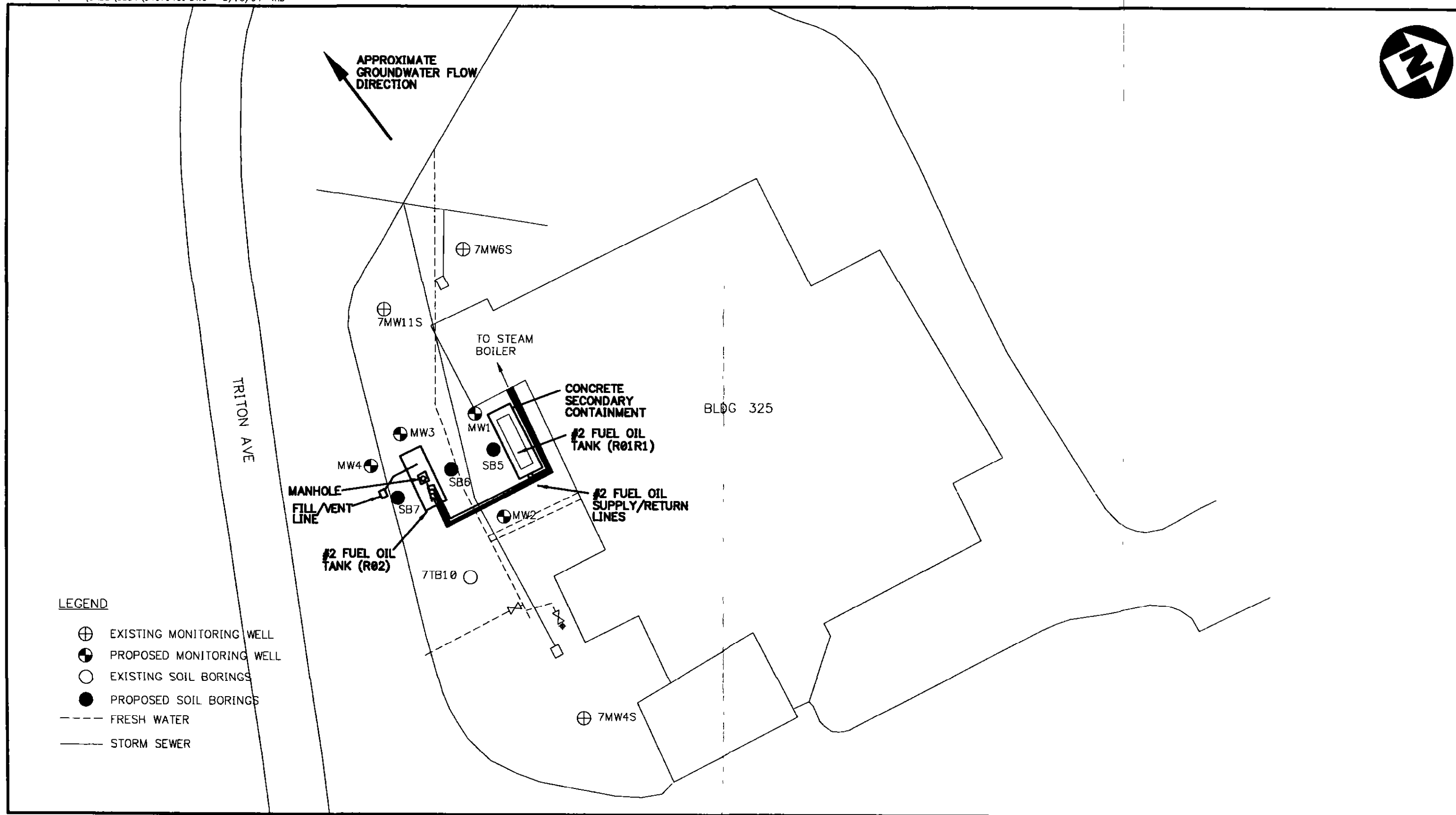
12-4



**SAMPLE LOCATIONS**  
**OT - 10**  
**SUBASE - NEW LONDON, CT**



**FIGURE 3-1**



**SAMPLE LOCATIONS**  
**BUILDING 325 - #2 FUEL OIL TANK**  
**SUBASE - NEW LONDON, CT**

**FIGURE 3-2**





sample volume requirements for chemical analysis. The use of drilling fluids is prohibited while drilling. All samples recovered from the boreholes will be screened with a PID or FID organic vapor monitor. Chemical analysis for individual borings is described in the following sections.

#### **3.4.1     OT-10**

A total of eight borings shall be drilled at OT-10 at the proposed locations shown on Figure 3-1. Borings will be advanced to the water table. Soil samples will be collected continuously from each soil boring at 2-foot intervals for the entire length of the boring to log physical characteristics (such as color, lithology, and moisture) of the soil and any visible evidence of contamination. All soil samples shall be field screened with a FID organic vapor monitor to estimate the vertical extent of contamination present. One soil sample will be collected from each boring (MW-01 through MW-08) from immediately above the water table for laboratory analyses to determine if contamination is present at that location. An additional four soil samples will be collected at depth for analyses from borings based on the highest field screening results with a FID or the presence of contamination based on visual observations, and/or noticeable odors, in order to determine the vertical extent of contamination present. The soil samples taken from immediately above the water table in the downgradient well borings MW-02, MW-03, MW-04, MW-06, MW-07, MW-08 and the four additional soil samples based on FID results will be analyzed for TPH and BTEX, as these are the contaminants most likely to be encountered at this site. Soil samples collected from the upgradient well (MW-01) and from the well (MW-05) downgradient of the leaking tank will be analyzed for TPH, TCL volatiles, TCL semivolatiles, TCL pesticides/PCBs, TAL metals and full TCLP to identify the presence of the contaminants of concern in the soil, and also to identify contamination from any extraneous upgradient sources or contamination downgradient, respectively.

#### **3.4.2     B-325**

A total of seven borings shall be drilled at B-325 at the proposed locations shown on Figure 3-2. Borings will be advanced to the water table. Soil samples will be collected continuously from each soil boring at 2-foot intervals for the entire length of the boring to log physical characteristics (such as color, lithology, and moisture) of the soil and any visible evidence of contamination. All soil samples shall be field screened with a FID organic vapor monitor to estimate the vertical extent of contamination present. One soil sample will be collected from each boring (MW-1 through MW-4 and SB-5 through SB-7) from immediately above the water table for laboratory analyses to determine if contamination is present. An additional four soil samples will be collected at depth for analyses from borings based on the highest field screening results with a FID or the presence of contamination based on visual observations, and/or noticeable odors, in order to determine the vertical extent of contamination present. All soil samples collected will be analyzed for TPH

and BTEX, as these are the contaminants most likely to be encountered at this site. In addition, the soil sample collected from the downgradient well MW3 will be analyzed for full TCLP to identify contaminants which may influence soil remediation.

### **3.5 MONITORING WELL CONSTRUCTION**

Eight permanent monitoring wells will be installed at OT-10, and four permanent wells will be installed at B-325.

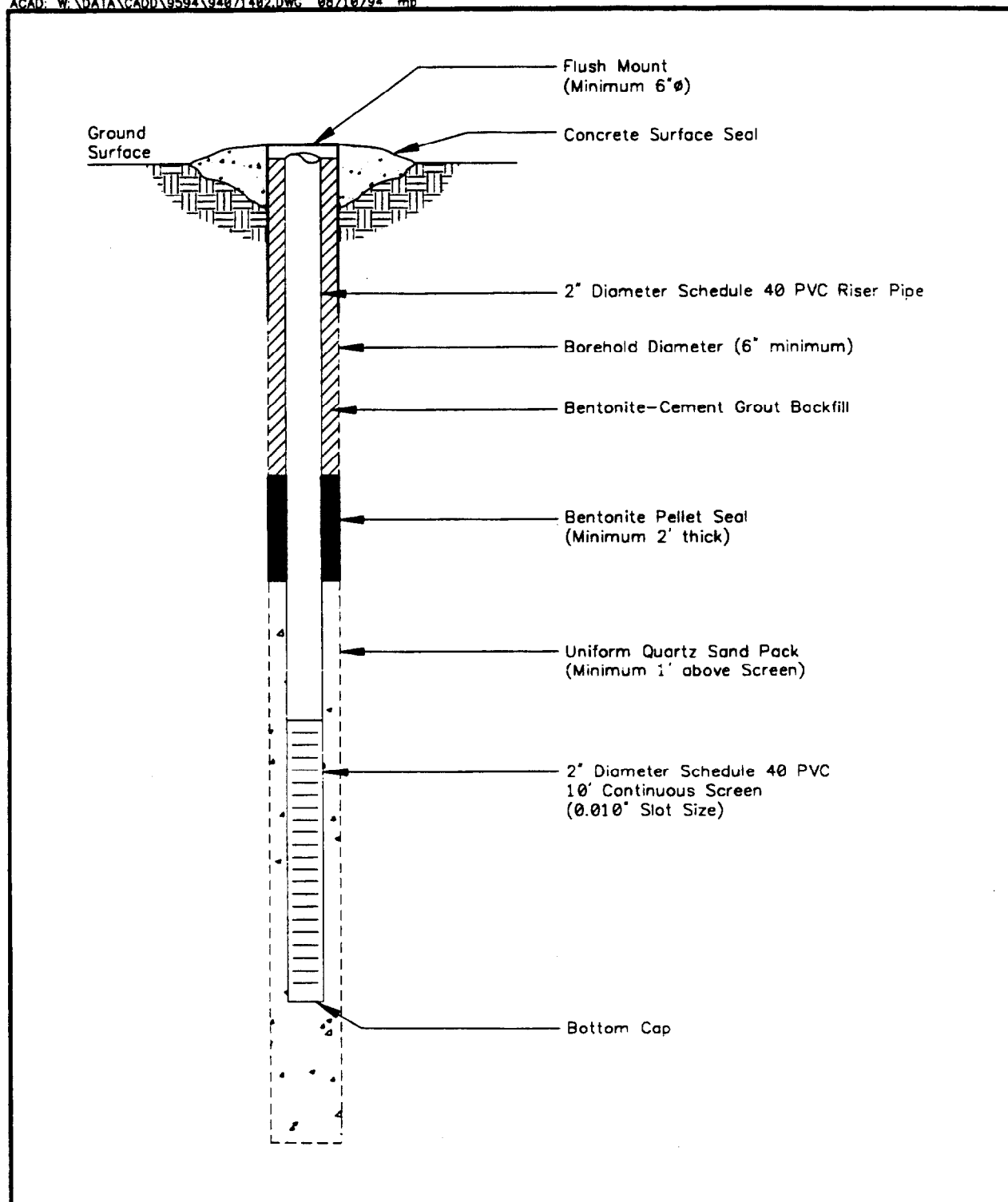
After the soil borings have been drilled to the desired depth using hollow-stem augers (8-inch minimum borehole diameter), the well screen and riser pipe will be installed through the augers to the desired depth. The well screen will intersect the water table, and the top of the well screen will be at least 2 feet above the static water elevation to allow for seasonal fluctuation of the water table. The annulus of the boring around the well screen will be backfilled with clean silica sand to a depth of at least 1 foot above the well screen. A bentonite pellet seal (minimum 2-foot thickness) will then be installed above the sand pack and allowed to hydrate as per manufacturer's recommendations. The remainder of the boring annulus will be backfilled to a depth of 1 foot below ground surface with a cement/bentonite grout using a tremie pipe.

All monitoring wells will be constructed of 2-inch inside diameter, Schedule 40 PVC, flush-joint riser pipe and flush-joint, factory-slotted well screen. All well screens will be 10 feet in length and have a slot size of 0.010 inch.

A 6- or 8-inch steel protective casing will be installed flush with ground surface around each monitoring well. A sloping concrete pad will be constructed around the flush-mounted casing to prevent pooling of water over the well. A monitoring well construction form will be completed for each monitoring well in accordance with SOP GH-1.7. A typical monitoring well construction diagram is given in Figure 3-3.

All monitoring wells will be developed to remove any fine material from the area around the well screen. The monitoring wells will be developed by air lift, bailing and surging, or pumping, as determined by the field geologist. Each monitoring well will be developed until the water removed is visibly clear of suspended solids or until approved by the field geologist. Wells will not be developed until a minimum of 24 hours has elapsed after installation of the cement/bentonite grout.

Based on the soil boring and monitoring well installation techniques outlined above for sites at OT-10 and B-325, the following guidelines under EPA Technical Standards for Owners and Operators of Underground Storage Tanks (Federal regulations 40 CFR 280.43) will be satisfied.



TYPICAL SHALLOW PVC MONITORING WELL  
SUBASE - NEW LONDON, GROTON CONNECTICUT

FIGURE 3-3



- The slotted portion of the monitoring well casing will be designed to prevent migration of natural soils or filter pack into the well and to allow entry of regulated substance on the water table into the well under both high and low groundwater conditions.
- The monitoring wells will be sealed from the ground surface to the top of the filter pack.
- The monitoring wells will intercept the excavation zone, or will be as close as technically feasible.
- The methods used to check for floating product will be able to detect at least one-eighth inch of floating product on top of groundwater in the monitoring wells.
- The monitoring wells will be positioned to detect releases from any portion of the tanks or lines that routinely contain product.
- Monitoring wells will be clearly marked and secured to avoid unauthorized access and tampering.

In addition, site conditions present at OT-10 and B-325 conform with the following requirements established by Federal Regulations 40 CFR 280.43:

- The regulated substances in the tanks (waste oil and diesel fuel) are immiscible in water and have a specific gravity of less than one.
- The groundwater at these sites is approximately 5 feet from ground surface, and is never more than 20 feet from ground surface. The soils underlying the site are permeable, and consist of fine to coarse sands and have hydraulic conductivities of greater than 0.01 cm/sec.

### **3.5.1 Permanent Monitoring Wells at OT-10**

A total of eight wells will be installed at OT-10 to determine the extent of groundwater contamination, if present, at the site. In addition, all eight wells will serve as a permanent leak detection system for the tanks at OT-10, which will continue to receive waste oil from oil-water separator activities. Proposed well locations are shown on Figure 3-1. One well (MW-01) will be located in the inferred upgradient direction (east) from the tanks at OT-10. This well will determine the base line quality of groundwater upgradient of the site and will aid in defining groundwater flow direction. Two monitoring wells (MW-02 and MW-03) will be located

downgradient of tank NN-02 and the associated supply lines. These wells will detect any contamination which may be currently present, and will be part of the leak detection program for this tank and the supply lines. One well (MW-04) will be located immediately downgradient from the truck dumping pad to determine groundwater quality in this area, and to detect any future releases which may occur from this pad or the 8-inch line, which runs from the pad to tank NN-03. Two wells (MW-05 and MW-06) will be located directly downgradient from tank NN-02 to detect any groundwater contamination which may have been released from this tank. Two wells (MW-07 and MW-08) will be located directly downgradient of the oil/water separator to determine if any releases have occurred.

### **3.5.2      Permanent Monitoring Wells at B-325**

A total of four permanent monitoring wells will be installed at B-325 to determine the extent of groundwater contamination, if present, at the site. In addition, these wells will be used as part of the leak detection system for the remaining tank and its supply and return lines at B-325, which will continue to supply No. 2 fuel oil to Building 325. Proposed well locations are shown on Figure 3-2. One monitoring well (MW-2) will be located upgradient from tanks R01R1 and R02 and their associated lines. This well will determine the baseline quality of groundwater upgradient of the site and will also aid in determining groundwater flow direction at this site. One monitoring well (MW-1) will be located downgradient of tank R01R1 and associated lines, and two monitoring wells (MW-3 and MW-4) will be located downgradient of tank R02 and its fill and vent lines. The downgradient wells will detect any groundwater contamination which may have been released by the tanks R01R1 or R02 and identify which tank has leaked. It will also be used as part of the leak detection system for the site.

### **3.6              GROUNDWATER SAMPLING**

Groundwater samples will be collected using a peristaltic sampling pump with a low-flow sample rate to minimize sample turbidity. Prior to obtaining the groundwater samples, the static water level shall be measured to determine the amount of water in one casing volume. The wells shall be purged at a rate of 0.3 liters per minute using a low-flow suction lift peristaltic pump and dedicated hose to minimize turbulence. Measurements of pH, specific conductance, temperature, oxidation reduction potential (REDOX), and turbidity shall be recorded every 5 minutes during purging in accordance with SOP SF-1.1. If two consecutive readings of pH, specific conductance, temperature, REDOX, and turbidity are similar ( $\pm 10$  percent) after three well volumes have been purged, then the well may be sampled. Purging will continue until stabilization of readings is achieved or a maximum of five casing volumes is purged, whichever occurs first. One measurement of dissolved oxygen shall also be taken prior to sample collection, in accordance with SOP SF-1.1. If the well is purged dry before three casing volumes, the water level will be

allowed to recover and a sample shall be taken. In the event that recovery is too slow to adequately fill all sample bottles, the sample shall be collected the following day.

The wells shall be sampled directly from the pump outlet for all analytes except volatile analyses with a flow rate of 0.3 liters per minute. Sample vials for volatile analyses will be filled by crimping the discharge end of the sample tubing when filled, while removing the inlet end of the sample tubing from the well. The inlet end will be suspended above the vial and the discharge end will be opened, allowing water to fill each vial by gravity flow. Purge water shall be containerized pending analysis. The groundwater samples shall be collected in accordance with SOP SA-1.1.

### **3.6.1      OT-10**

Groundwater samples will be collected from each of the eight monitoring wells. Samples from the upgradient well (MW-01) and from wells immediately downgradient tanks NN-02 and NN-03 (MW-03 and MW-05) will be analyzed for TCL volatiles, TCL semivolatiles, TCL pesticides/PCBs, and TAL metals to identify the presence of the contaminants of concern in the groundwater and to provide a broad characterization of groundwater quality at the site. Samples from the remaining wells downgradient of the fuel lines, the truck dumping pad and the oil/water separator (MW-02, MW-04, MW-06, MW-07, and MW-08) will be analyzed for TPH and BTEX to identify the presence of the contaminants of concern in the groundwater in these areas. A summary of the samples to be collected at OT-10 is included in Table 3-1.

### **3.6.2      B-325**

Groundwater samples will be collected from each of the monitoring wells. All samples will be analyzed for TPH and BTEX to identify the presence of the contaminants of concern in the groundwater and to provide a broad characterization of groundwater quality at the site. A summary of the samples to be collected at B-325 is included in Table 3-1.

## **3.7            WASTE WATER/WASTE OIL SAMPLING**

Contaminants in the tanks at OT-10 are presently unknown. The waste oil and waste water at OT-10 will be sampled to determine which compounds are present in the waste material. One waste water sample will be taken from the 30,000-gallon tank (NN-03), and one waste oil sample will be taken from the 10,000 gallon tank (NN-02). Both the waste oil and waste water samples will be analyzed for TPH, TCL volatiles, TCL semivolatiles, TCL pesticides/PCBs and TAL metals to fully identify any possible contaminants.

The waste oil and waste water will be sampled using a kemmerer sampler lowered into the tank through the manhole or other opening. If possible, the level of waste oil and/or waste water in each tank will be determined before sampling using a hydrocarbon interface probe. The NN-03 tank contains both oil and water. The waste water sample will be collected from the bottom of the tank. Tank NN-02 contains only waste oil, and the waste oil sample will be collected from the top layer of the tank. One measurement of pH, specific conductance, temperature, ORP, and dissolved oxygen will be taken prior to sample collection in accordance with SOP SF-1.1.

### **3.8 WATER LEVEL MEASUREMENTS**

Two complete rounds of water elevations will be collected at each site to determine groundwater flow directions. Groundwater level measurements will be taken from newly installed monitoring wells. Water levels will be taken using a hydrocarbon interface probe, which can detect the presence or absence of floating hydrocarbons on the surface of the water table.

In addition to water level measurements, the top of the water table at each well will be observed using a clear bailer to confirm the presence or absence of a floating product layer. The bailer will be lowered down the well and submerged less than the total length of the bailer, then removed and visually examined. This method will allow the field geologist to observe the apparent thickness and characteristics of any petroleum layer which may be present. This method can also be used to observe a thin film which may not be detectable by the hydrocarbon interface probe.

### **3.9 DECONTAMINATION**

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes downhole drilling tools, augers, and all non-dedicated sampling equipment. Specific decontamination procedures are discussed in the following subsections.

#### **3.9.1 Major Equipment**

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well riser pipe and screen shall be steam cleaned prior to being installed into the borings unless the well materials arrive at the site in factory sealed plastic covers.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at the designated decontamination area. Additional requirements for drilling equipment decontamination can be found in Halliburton NUS SOP GH-1.6.

### **3.9.2      Sampling Equipment**

All sampling equipment used for collecting samples (i.e., split-spoons, bailers) will be decontaminated both prior to field sampling and between samples, in accordance with SOP SF-2.3. The following decontamination steps will be taken:

- Potable water and Alconox or Liquinox detergent wash
- Potable water rinse
- Methanol rinse
- Hexane rinse
- Distilled/Deionized water rinse (analyte free)
- Air dry

Field analytical equipment such as instrument probes will be rinsed first with analyte-free water, then with the sample liquid.

### **3.10      WASTE HANDLING**

All decontamination and purge liquids will be collected, containerized, and stored on site in Department of Transportation (DOT)-approved (Specification 17-C), 55-gallon drums. All drill cuttings will also be collected and stored on site in the DOT-approved drums. All drums will be sealed and labeled with drum contents, well/boring number, site or origin, volume, and date. The drums will be stored at a centralized location on base pending analyses results. Halliburton NUS will dispose of the waste in an appropriate manner based on the analyses results.

### **3.11      SAMPLING IDENTIFICATION SYSTEM**

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alpha-numeric code that identifies the site, the sample medium and location, and sample depth (in the case of soil samples). Any other pertinent information regarding sample identification will be recorded in the field log books and sample logsheets.



The alpha-numeric coding to be used in the sample system is explained in the following diagram and the subsequent definitions:

(AANNN)	-	(AANN)	-	(NNNN)
(Site)		(Medium & Location)		(Sample depth)

**Character Type:**

A = Alpha  
N = Numeric

**Site:**

OT10 = Oil Tank 10 Site  
B325 = Building 325 Site

**Medium:**

GW = Groundwater  
SO = Soil samples

**Sample Location:**

Monitoring well or soil boring number (numeric, starting with 01 for each medium)

**Sample Depth:**

For soil samples only = Start and end depth, in feet, of sample

Example: A soil sample taken from the OT-10 site from well boring MW01 at a depth of 2 to 4 feet would be numbered OT10-SO01-0204.

Field quality control (QC) samples will be designated using a coding system. QC samples such as duplicates, field blanks, trip blanks and rinsate blanks will be numbered sequentially, with each successive QC sample designation being increased by one, per sample, regardless of media. The designation will

consist of a two-segment, alpha-numeric code that identifies the QC sample identifier and number. Note that the time for duplicates will be noted as 0000 on the sample labels and the chain-of-custody. The actual time of sampling and duplicate sample location will be noted in the field notebook and on the sample log sheets. This will allow duplicates to be shipped to the laboratory without providing information as to their location. Following is a summary of the QC sample coding system.

DUPLICATE	=	Duplicate sample
TB	=	Trip Blank
FB	=	Field Blank
RB	=	Rinsate Blank

Examples: The first sample duplicate would be designated as:

DUPLICATE-01, with time noted on the sample label and chain-of-custody as 0000.

The second duplicate, regardless of media, would be labeled as:

DUPLICATE-02, with time noted on the sample label and chain-of-custody as 0000.

Other QC samples will be labeled in a similar fashion.

### **3.12 SAMPLE PRESERVATION, PACKAGING AND SHIPPING**

Samples will be preserved in accordance with SOP SF-1.2. Sample bottle requirements, preservation requirements, and holding times are provided in Table 3-2. Samples will be packaged and shipped in accordance with Halliburton NUS SOP SA-6.2. The following forms will be completed during the field activity:

- Sample Labels
- Chain-of-Custody Forms
- Chain-of-Custody Seals
- Sample Logsheets
- Overnight Courier Air Bills

Copies of applicable forms are included in Halliburton NUS SOP SA-6.4

TABLE 3-2

**SUMMARY OF ANALYSIS, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS  
AND HOLDING TIMES  
OT-10 AND B-325 SITES  
NSB-NLON, SUBASE, NEW LONDON, CONNECTICUT**

Media	Analysis	No. of Containers Per Sample	Container Type	Preservation Requirements	Holding Times <sup>(1)</sup>
Groundwater/ Aqueous Tank Contents	TPH	1	1-L glass	H <sub>2</sub> SO <sub>4</sub> , pH < 2, 4°C	28 days
	BTEX	2	40-mL VOA vial	HCl, pH < 24°C	14 days
	TCL VOC	3	40-mL VOA vial	HCl, pH < 24°C	14 days
	TCL Semivolatiles	1	1/2-gallon amber glass jug	4°C	7 days to extract; 40 days to analyze
	TAL Metals	1	1-L polyethylene bottle	HNO <sub>3</sub> , pH < 2, 4°C	180 days; Hg 28 days
	TCL Pesticides/PCBs	1	1/2-gallon glass jug	4°C	7 days to extract; 40 days to analyze
Soil/Oil Tank Contents	TPH	1	4-oz. clear wide-mouth glass jar	4°C	28 days
	BTEX	1	4-oz. clear wide-mouth glass jar	4°C	14 days
	TCL VOC	1	60-mL glass VOA vial	4°C	14 days
	TCL Semivolatiles	1	8-oz. clear wide-mouth glass jar	4°C	7 days to extract; 40 days to analyze
	TAL Metals	1	4-oz. clear wide-mouth glass jar	4°C	180 days; Hg 28 days
	Full TCLP	1	4-oz. clear wide-mouth glass jar	4°C	7 days
	TCL Pesticides/PCBs	1	8-oz. clear wide-mouth glass jar	4°C	7 days to extract; 40 days to analyze

<sup>(1)</sup> Holding times measured from date of sample collection.

### 3.13 SAMPLE CUSTODY

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. Section 5.3 of Halliburton NUS SOP SA-6.1 provides a description of the chain-of-custody procedures to be followed.

### 3.14 QUALITY CONTROL SAMPLES

In addition to standard sample acquisition, quality control (QC) samples will be collected or generated during the sampling activities. QC samples include trip blanks, field duplicates, field blanks, and equipment rinsate blanks. Table 3-1 presents the type and number of required QC samples. Each type of field QC sample is defined as follows:

- **Trip Blanks.** Trip blanks are samples which originate from analyte-free water collected in sample vials at the point of origin of the sample containers. The vials are shipped with the sample containers to the sampling site and returned to the laboratory with the Volatile Organic Compound (VOC) or BTEX samples. One trip blank is assigned to each cooler containing VOCs or BTEX. Trip blanks are only analyzed for VOCs or BTEX.
- **Field Duplicates.** A field duplicate is one sample collected that is split into two portions and analyzed in duplicate. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Field duplicates shall be analyzed in the laboratory for the same parameters as the associated environmental samples. The time for duplicates will be noted as 0000 on the sample labels and the chain-of-custody. The actual time of sampling and duplicate sample location will be noted in the field notebook and on the sample log sheets.
- **Equipment Rinsate Blanks.** Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (split-spoon or chisel) after decontamination and placing the runoff water in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of nondedicated sampling equipment used and will be submitted at a frequency of one per day per sampling event. However, only every other day's samples will be analyzed. Those not analyzed will be marked "hold" on the associated chain-of-custody form and will be retained by the laboratory until

completion of field activities. Equipment rinsate blanks are analyzed for the same parameters as the associated samples.

- **Field Blanks**. Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of the source water used in: (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures, and to determine if the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per source per sampling event (two estimated). Field blanks are analyzed for the entire suite of project parameters (excluding TCLP analyses).

### **3.15 EQUIPMENT CALIBRATION**

Several monitoring instruments may be used during field activities; these include

- Organic vapor monitor
- Temperature probe
- Specific conductance meter
- pH meter
- Turbidity meter
- Oxidation reduction potential meter
- Dissolved Oxygen meter
- Electronic water level meter

The electronic water level meter will be calibrated prior to mobilization and periodically at the discretion of the FOL. The remaining instruments will be calibrated daily or according to the manufacturer's operating manual.

Calibration will be documented in the field logbook. During calibration an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

### **3.16 RECORD KEEPING**

In addition to the previously mentioned forms, other types of records must be kept. These records include notebooks and logbooks.

A bound/weatherproof field notebook shall be maintained by the field crew. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

A bound/weatherproof site logbook shall be maintained by the FOL. The requirements of the site logbook are outlined in Halliburton NUS SOP SA-6.3, Sections 5 and 7. This book will contain a summary of the day's activities and will reference the field notebooks when applicable.

At the completion of field activities, the FOL shall submit to the Project Manager (PM) all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample logsheet, drilling logs, etc. Required changes to the work plan will be discussed with the PM/FOL, and the PM will discuss these changes with the Navy RPM. Any changes to this work plan made in the field will be documented via Task Modification Request forms. A copy of the logbook will be made and sent to NORTHDIV.

### **3.17 SURVEYING**

The locations of all newly installed permanent monitoring wells will be surveyed by a licensed surveyed. The horizontal location and vertical elevation of each well will be noted, including the elevation of the riser, top of casing and ground surface elevation at the well. Elevations will be reported in feet above mean sea level to the nearest 0.01 foot. Surveying will utilize pre-existing reference points and/or existing survey monuments from previous surveying events.

## **REFERENCES**

Halliburton NUS Corporation, April 1994. Site Characterization Report for Waste Oil Tank 5 for Naval Submarine Base - New London, Groton, Connecticut.

Halliburton NUS Corporation, October, 1994. Health and Safety Plan for Phase II Remedial Investigation for Naval Submarine Base - New London, Groton, Connecticut.

## **APPENDIX A**

### **STANDARD OPERATING PROCEDURES (SOPs) NSB-NLON, SUBASE-NEW LONDON GROTON, CONNECTICUT**



## **STANDARD OPERATING PROCEDURES**

GH-1.3	Soil and Rock Sampling
GH-1.5	Borehole and Sample Logging
GH-1.6	Decontamination of Drilling Rigs and Sample Equipment
GH-1.7	Groundwater Monitoring Point Installation
GH-2.5	Water Level Measurement/Contour Mapping
SA-1.1	Groundwater Sample Acquisition
SA-6.1	Sample Identification and Chain-of-Custody
SA-6.2	Sampling Packaging and Shipping
SA-6.3	Site Logbook
SA-6.4	Forms Used in RI Activities
SF-1.1	On-Site Water Quality Testing
SF-1.2	Sample Preservation
SF-2.3	Decontamination of Chemical Sampling and Field Analytical Equipment
ASTM D 1586-84	Penetration Test and Split-Barrel Sampling of Soils

Subject  SOIL AND ROCK SAMPLING	Number GH-1.3	Page 3 of 13
	Revision 2	Effective Date 05/04/90

## 5.0 PROCEDURES

### 5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

#### 5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. ( $\pm 2$  lb.) weight, driving head and guide permitting free fall of 30 inches ( $\pm 1$  inch).
- Drive weight assembly, 300-lb. ( $\pm 2$  lb.) weight, driving head and guide permitting free fall of 18 inches ( $\pm 1$  inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

Subject  SOIL AND ROCK SAMPLING	Number GH-1.3	Page 4 of 13
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### 5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.
- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.
- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. ( $\pm 2$  lb.) hammer falling 30 inches ( $\pm 1$  inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.
- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are encountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.
- Repeat this operation at intervals not greater than .5 feet in homogeneous strata, or as specified in the sampling plan.
- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.
- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

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- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

### 5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.
- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.
- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.
- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.
- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

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sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

#### 5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

#### 5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.
- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.
- Pack and ship accordingly.
- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

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### 5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.
- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.
- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

### 5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

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# ATTACHMENT 1

## STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	1 $\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	1 $\frac{1}{8}$	$\frac{29}{32}$	1.470	.905
EX, EXL, EWG, EWM	1 $\frac{1}{2}$	$\frac{13}{16}$	1.470	.845
AWT	1 $\frac{7}{8}$	1 $\frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	1 $\frac{5}{8}$	1 $\frac{3}{16}$	1.875	1.185
BWT	2 $\frac{3}{8}$	1 $\frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	2 $\frac{3}{8}$	1 $\frac{5}{8}$	2.345	1.655
NWT	3	2 $\frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	2 $\frac{1}{8}$	2.965	2.155
HWT	3 $\frac{29}{32}$	3 $\frac{3}{16}$	3.889	3.187
HWG	3 $\frac{29}{32}$	3	3.889	3.000
2 $\frac{3}{4}$ x 3 $\frac{7}{8}$	3 $\frac{7}{8}$	2 $\frac{3}{4}$	3.840	2.690
4 x 5 $\frac{1}{2}$	5 $\frac{1}{2}$	4	5.435	3.970
6 x 7 $\frac{3}{4}$	7 $\frac{3}{4}$	6	7.655	5.970
AX Wire line $\perp$	1 $\frac{7}{8}$	1	1.875	1.000
BX Wire line $\perp$	2 $\frac{3}{8}$	1 $\frac{7}{16}$	2.345	1.457
NX Wire line $\perp$	3	1 $\frac{15}{16}$	2.965	1.957

\* All dimensions are in inches; to convert to millimeters, multiply by 25.4.  
 $\perp$  Wire line dimensions and designations may vary according to manufacturer

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Size Designations		Casing O.D., inches	Casing coupling		Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings		O.D., inches	I.D., inches				Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

\* For hole diameter approximation, assume  $\frac{1}{32}$  inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.



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Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

#### 5.4.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.
- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.
- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.
- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.
- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

#### 5.4.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g.,

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To prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

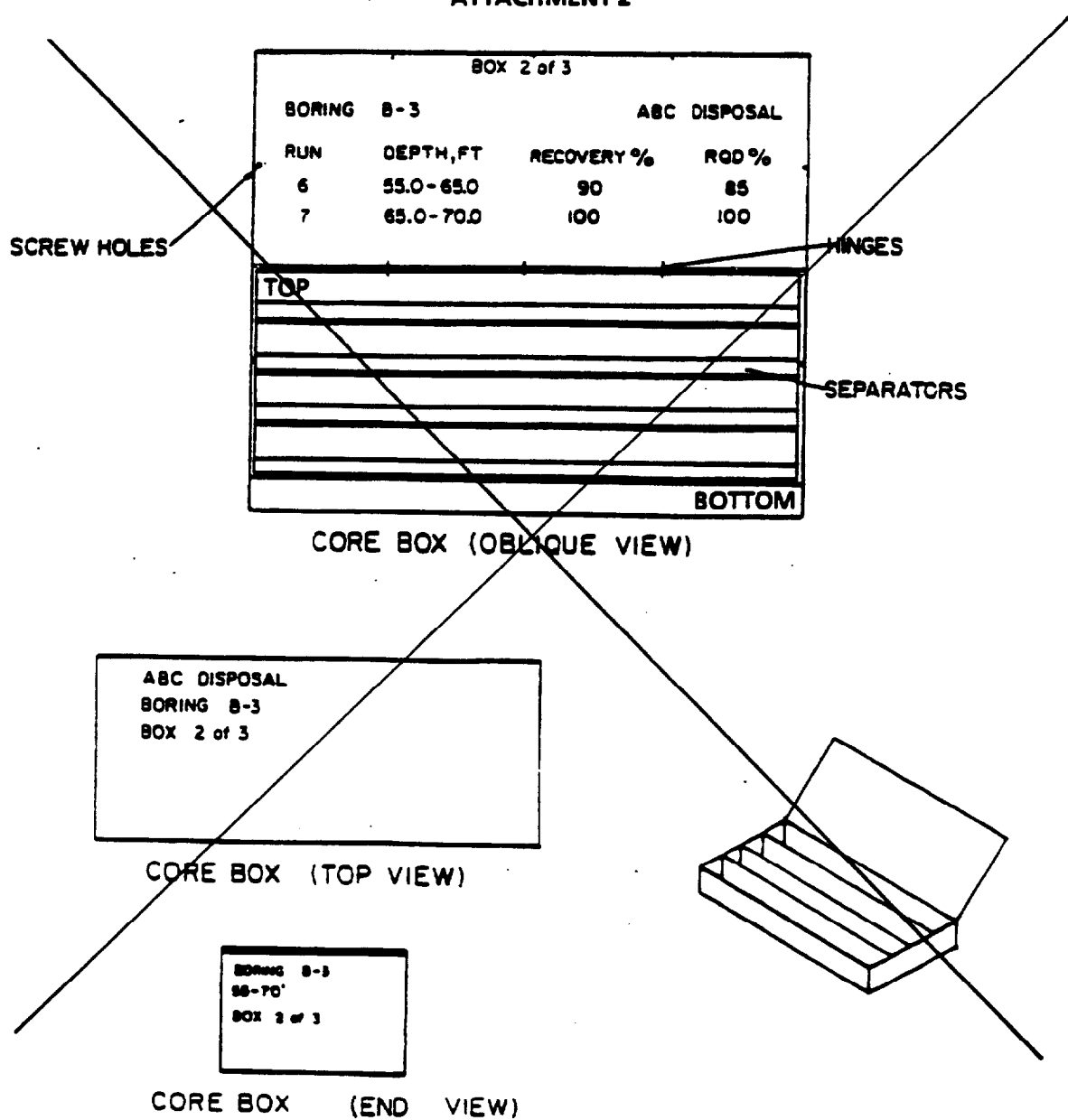
- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

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## ATTACHMENT 2



TYPICAL ROCK CORE BOX

NOT TO SCALE



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## 6.0 REFERENCES

American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, Pennsylvania.

American Society for Testing and Materials, 1989. Standrd Practice for Diamond Core Drilling for Site Investigation. ASTM Method D2113-83 (reapproved 1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U.S. Department of the Interior, 1974, Earth Manual, A Water Resources Technical Publication, 810 pages.

Central Mine Equipment Company, Drilling Equipment, St. Louis, Missouri.

## 7.0 RECORDS

None.

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## 1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

## 2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

## 5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

### 5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

### 5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

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### 5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inch $\phi$ -1/2 inch $\phi$ ) or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

### 5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

### 5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

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Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

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#### 5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

#### 5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

#### 5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

#### 5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).



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### 5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

### 5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ( $\text{CaCO}_3$ ). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

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### 5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

### 5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts shall not be used unless specified by the project manager.

### 5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

### 5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

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### 5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V: BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

#### Method of Calculating RQD (After Deere, 1964)

$$RQD \% = r/l \times 100$$

$r$  = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

$l$  = Total length of the coring run.

### 5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

### 5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic)

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- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

### 5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

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The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

#### 5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

#### 5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

##### 5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

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- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.
- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:
  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
  - Particle shape - flat, elongated, or flat and elongated.
  - Maximum particle size or dimension.
  - Water level observations.
  - Reaction with HCl - none, weak or strong.

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- **Additional comments:**

- Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
- Indicate odor and HNu or OVA reading if applicable.
- Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.
- At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).
- Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.
- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

#### 5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

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- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.
- As a final check the boring log shall include the following:
  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

### 5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to



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provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

#### **5.6 REVIEW**

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

#### **6.0 REFERENCES**

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

#### **7.0 RECORDS**

Originals of the boring logs shall be retained in the project files.



## SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)										
COARSE GRAINED SOILS More than half of material is LARGER than No. 200 sieve size					FINE GRAINED SOILS More than half of material is SMALLER than No. 200 sieve size					
FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYM-BOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYM-BOL	TYPICAL NAMES	
GRAVELS 50% $\frac{3}{16}$ " to 3" 100% $\frac{1}{2}$ " to 3"	CLEAN GRAVELS Less than 5% fines	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel sand mixtures, little or no fines	Identify these procedures on fraction smaller than No. 40 sieve size			ML CL OL MH CH OH Pt		
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel sand mixtures, little or no fines	SILTS & CLAYS Liquid limit $\leq 50$	LOW STRENGTH (If crushing characteristics)	DELTANCY (Reaction to Shaking)			TOUGHNESS (If necessary for or Plastic Limit)
	GRAVELS WITH FINES More than 5% fines	Non plastic fines (for identification procedures see M1)	GM	Silty gravels, poorly graded gravel sand silt mixtures		None to slight	Quick to slow			None
		Plastic fines (for identification procedures see C1)	GC	Clayey gravels, poorly graded gravel sand clay mixtures		None to high	None to very slow			Medium
SANDS 50% $\frac{3}{16}$ " to 3" 100% $\frac{1}{2}$ " to 3"	CLEAN SANDS Less than 5% fines	Wide range in grain size and substantial amounts of all intermediate particle sizes	SW	Well graded sand, gravelly sands, little or no fines	SILTS & CLAYS Liquid limit $> 50$	Slight to medium	Slow	Slight	OL	Organic silts and organic silt clays of low plasticity
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines		Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clean silts
	SANDS WITH FINES More than 5% fines	Non plastic fines (for identification procedures see M1)	SM	Silty sands, poorly graded sand silt mixtures		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
		Plastic fines (for identification procedures see C1)	SC	Clayey sands, poorly graded sand clay mixtures		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
					HEAVY ORGANIC 10% +	Readily identified by color, odor, sponge test and frequently by laboratory tests.			Pt	Peat and other organic soils

Boundary classification: Soil possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.  
All sieve sizes on this chart are U.S. standard

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

## ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)		
DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS		
DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V.B.)	0 - 2"
Broken	(B.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

## LEGEND

## SOIL SAMPLES - TYPES

- 1 2" O.D. Split Barrel Sample
- 11 3" O.D. Undisturbed Sample
- 0 Other Samples, Specify in Remarks

## ROCK SAMPLES - TYPES

- 11 1/2" (Conventional) Core (-2 1/4" O.D.)
- 01 (Machine) Core (-1 1/4" O.D.)
- 2 Other Core Sizes, Specify in Remarks

## WATER LEVELS

- 12-10 T-11A Initial Level - Above & Depth
- 12-10 T-11A Standstill Level - Above & Depth

EXHIBIT 4-2

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### EXHIBIT 4-3

#### CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

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#### EXHIBIT 4-4

##### BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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**EXHIBIT 4-5**

**GRAIN SIZE CLASSIFICATION FOR ROCKS**

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

Subject

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## BORING LOG

NUS CORPORATION

PROJECT HEBELKA SITE

BORING NO: MW 3A

PROJECT NO: 619Y

DATE: 9-21-87

DRILLER: B. GOLLINGUE

ELEVATION: 510.07

FIELD GEOLOGIST: SJ CONTI

WATER LEVEL DATA

WL 26.35 - TPVC 10-16-87

(Date, Time &amp; Conditions)

SAMPLE NO or TYPE RQD	DEPTH IN / FEET	BLOWS 6" OR 10"	RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE NUMBER / 1 OR SCHEMATIC ENT	MATERIAL DESCRIPTION*			REMARKS
					SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	
S-1	0.0	3	1.5		STIFF	BRN	CLAYEY SILT-TR SHALE	ML 0-6" TOPSOIL MOIST OPPM
	1.5	6					FRAG-TR ORG.	RESIDUAL SOIL
	5.0							
S-2	6.0	11	6.8	5.5	M.SOFT	GRAY BRN	DEC SHALE AND SILT	VER DAMP OPPM
				6.0	TO			REFUSAL @ 6' 5.5 TOP OF DEC ROCK
					M.HARD			INCREASED TO 15' W/SOLID STEM AVG. CUTTING MOIST @ 28' WATER @ 11'±
								WL @ 12:10 PM WAS ± 9' FROM GS.
								SET 4" PVC CAS. @ 12.0'
9-21	15.0							
9-22					M.HARD	BRN GRAY	SILTY SHALE - FEW QUARTZ PCS	VER SEVERAL 0 FPM Fe STAINED JOINTS ON CORE THROUGHOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO 2. W/ XUGS ON LOWER PORTION 23 TO 25 OF CORE
23	20.0	28	7.9	0.0				
	25.0							

REMARKS ACKER AD II RIG - SOLID STEM ALYERS USED TO ADVANCE

BORING-- 140 LB WIRE 30" DROP - TO TAKE 2" Ø SP. SP. SAMPLE

SAMPLES - SET UP OVER HOLE @ 11:10 AM. W/ILL SAMPLE

\* See Log on back THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL.

STARTED TO CORE 9-22-87 USING THE WIRE-LINE  
CORING METHOD.

BORING MW 3A

PAGE 1 OF 3

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BORING LOG						NUS CORPORATION	
PROJECT: <b>HEBELKA SITE</b>				BORING NO.: <b>MW 3A</b>			
PROJECT NO.: <b>619Y</b>				DATE: <b>9-22-87</b>		DRILLER: <b>B. GOLLHUE</b>	
ELEVATION:				FIELD GEOLOGIST: <b>SJ CONTI</b>			
WATER LEVEL DATA (Date, Time & Conditions)							
SAMPLE NO & TYPE RQD	DEPTH FT RUN	BLDNG 6" OR RQD 1" ±	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY Change (Depth ft)	MATERIAL DESCRIPTION*		REMARKS
					SOX DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR  MATERIAL CLASSIFICATION	
9-22	25.0				M.HARD	GRAY SILTY SHALE (SILTSTONE)	VBR SHALE IS VBR W/ HORIZ TO LD 4 INTS
						- FEW QUARTZ SEAMS	226 TO 27 2- VERT JOINTS. IRON STAINS ON JNTS ROCK BECOMES AND BREAKS MORE LIKE A SLTSTONE WITH DEPTH.
9/10.0	2	9%	8.7/10.0				BR 232 TO 33 FEW QUARTZ PIECES W/ VUGS.
							VBR SL MICACED & VF QUARTZ GRAINS IN MATRIX - SOX MAG.
	35.0						234 TO 35 2 VERT JOINTS
					M.HARD	GRAY SILTY SHALE (SILTSTONE)	VBR 35.0-35.5 QUARTZ PIECES
						- FEW QUARTZ SEAMS	BR BECOMES SL. CALCAR. & 37± THIN CALCITE LAMINATIONS.
							VBR WATER STAINED JNTS
							BR THROUGHOUT RUN MORE SO 35-37 ±
1-9/10.0	3	10%	9.7/10.0				VBR 39.5 → 42.0
							42.7 → 43.0 HI & JNT
							BR 42.4 → 42.7 VERT JNT
	45.0						VBR 45.3 → 45.5 VERT JNT. & VBR
							47.5 VERT JNT
							BR 48. HI & JNT
							SLIGHTLY CALCAREOUS MORE CALCITE PRESENT

REMARKS \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

BORING MW 3A

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\* See Legend on Back





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**EXHIBIT 4-6**

BORING LOG						NUS CORPORATION	
PROJECT: WESTLINE SITE				BORING NO.: MW 013			
PROJECT NO.: 475 Y				DATE: 7-7-87		DRILLER: B ERICSON	
ELEVATION: 1462.37				FIELD GEOLOGIST: SJ CONTI		PENN - DRILL	
WATER LEVEL DATA 5.54' @ 9:50 AM 7-23-87 T-PVC						ACKER AD-11	
(Date, Time & Conditions)							
SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN IN	SLOPE 5' OR ROD (ft)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (BOUNCE) OR MASONRY	MATERIAL DESCRIPTION		REMARKS (W.N.J.)
					SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	
	0.0	5	14/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINCEP ML MOIST (OPPM)
S-1		2					TR. COLL FEELS
							TR. CO FRAG
							(FILL)
	5.0						
S-2		1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT-TR TO S. S. GM MOIST TO WET (OPPM)
	6.5	3					SILTY SAND - TO GRAVEL
							GRAY SAND & G. S. 1/2" & 3/4" MAX. SIZE
							DRILLER NOTE H2O 8-10'
	10.0						
S-3		11	1.2/1.5		DENSE	BRN	SILTY SAND & FINE S.S. GM WET (OPPM)
	11.5	27					FRAGS (G.P.S.)
							1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUND GRAVEL
	15.0						
S-4		17	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND GM WET (OPPM)
	16.5	43					AND GRAVEL
							1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUND GRAVEL
	20.0						
S-5	20.9	17	1.9		V. DENSE	DRNG BRN	SILTY SAND - SOME GM WET (OPPM)
							GRAVEL AND
							S.S. FRAGS
							MOIST BECOMES MORE LIKE SANDY SILT AT BOTTOM OF SAMPLE

REMARKS: STAGE 1: 1:15 PIA - 7-7-87 USING 4 1/4" ID HOLLOW STIFF  
 S-4 @ 3:30 PM - TO ADVANCE THE BOREHOLE  
 S-5 @ 4:30 PM - ACKER DRILL - MONITORING OIL  
 TOYOL 8000 TRUCK  
 SAMPLES TAKEN  
 USING 140 lb WT AND 30 INCH DROP.

BORING MW 013  
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## BOREHOLE AND SAMPLE LOGGING

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## BORING LOG

**NUS CORPORATION**

PROJECT: WESTLINE SITE

BORING NO.: 143013

PROJECT NO.: 473Y

DATE: 7-7-87

DRILLER: E. EPSON

**ELEVATION:**

FIELD GEOLOGIST: S.J. CONTI

**WATER LEVEL DATA:**

(Date, Time & Conditions)

[illegible]

REMARKS S-6 @ 4:40 Fm

5-2 • 8:36 P.M. 7-E-87;

S-10 e 10:45 L.A. S-11 e

BORING MW013

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BORING LOG										NUS CORPORATION	
PROJECT: WESTLINE SRE										BORING NO.: MW 013	
PROJECT NO.: 473 Y										DATE: 7-9-87	
ELEVATION:										DRILLER: B. ECKSTADT	
WATER LEVEL DATA:										FIELD GEOLOGIST: SJ CONTI	
(Date, Time & Conditions)											
SAMPLE NO OR DEPTH	DEPTH PL. OR RUN NO.	BLOW COUNT (1")	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY (CHANGE NUMBER PL.) OR LITHOLOGY TEXT	MATERIAL DESCRIPTION			REMARKS			
					SOIL CONSISTENCY OR ROCK CLASSIFICATION	COLOR	MATERIAL CLASSIFICATION				
S-11	50.0	41	1.9	SE.0	V. DENSE GR. CLAY	GRAY BROWN	SILTY SAND - SOME GR. TR. CLAY	MOIST - (OPPM) FACILE W/ PCS OF BLACK COAL/LIGHT MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLAY.			
S-12	56.5	36	1.5		V. STIFF TO STIFF	GRAY ORANGE BROWN	SANDY CLAY / CLAYEY SAND SOME GR. / EL.	MOIST - (OPPM) NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLES - ROUNDED GRAINS FIRST COHESIVE TYPE CLASSIF.			
S-13	60.9	34	0.9		V. DENSE	ORANGE BROWN	SANDY CLAY / CLAYEY SAND - SOME GRAVEL.	MOIST - (OPPM) 1" AC THICK - CLAY AS S-12 BUT VERY COHESIVE. ROUNDED GRAINS SET CAS. 2' 00"			
7/13 S-14	65.8	37	0.8	SE.0	V. DENSE	BROWN ORANGE	SILTY SAND - SOME GR. AND ROCK FRAG - TR. CLAY	MOIST (OPPM) MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" D SIZE COLOR CHANGE AT 68' MORE SAND PER DRILLER - BOTH OF SEMI CLAY LAYER?			
7/14 S-15	71.5	41	1.5		V. DENSE	YELLOW BROWN	CLAYEY SAND (F.T.C.) SOME GRAVEL - TR ROCK FRAG.	MOIST - (OPPM) 1" MAX GRAVEL MORE GRAVEL @ 72' PER DRILLER			

REMARKS: 1) KING HOLLOW BOREHOLE - ADJUTANT BOREHOLE - DRILLING - 011  
 2) THIS BOREHOLE, UNITS REPEATED TO 71.5' IN SHAPE  
 S-12 @ 1:46 PM  
 S-13 @ 3:32 PM - LOGGED IN BY S-47 PM  
 SET 6" Ø STEEL CASING TO 60' - WILL DRILL DEEPER CASING  
 AFTER GROUT SETS UP. S-14 @ 3:00 PM 7-13-87  
 S-15 @ 7:57 AM 7-14-87

BORING MW 013  
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Subject  DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS	Number GH-1.6	Page 2 of 3
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## 1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

## 2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

## 5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program, all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

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Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

#### **6.0 RECORDS**

None.

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## **5.0 PROCEDURES**

### **5.1 EQUIPMENT/ITEMS NEEDED**

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

### **5.2 WELL DESIGN**

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

#### **5.2.1 Well Depth, Diameter, and Monitored Interval**

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of



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contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

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Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells, in-situ permeability tests can be performed during drilling or after well installation is completed.

#### 5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

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Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottawa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

### 5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

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In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

#### 5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

### 5.3 MONITORING WELL INSTALLATION

#### 5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

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The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

### 5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist; must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

### 5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

### 5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

### 5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

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Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. This system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

#### 5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

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to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

## 6.0 REFERENCES

Sclaf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

## 7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

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## ATTACHMENT A

**TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)**

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

### Preliminary Ranking of Rigid Materials

- 1 Teflon®
- 2 Stainless Steel 316
- 3 Stainless Steel 304
- 4 PVC 1
- 5 Lo-Carbon Steel
- 6 Galvanized Steel
- 7 Carbon Steel
- \* Trademark of DuPont

**RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)**

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®	Silicone	Neoprene	Teflon®
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

### Preliminary Ranking of Semi-Rigid or Elastomeric Materials

- 1 Teflon®
  - 2 Polypropylene (PP)
  - 3 PVC flexible/PE linear
  - 4 Viton®
  - 5 PE Conventional
  - 6 Plexiglas/Lucite (PMM)
  - 7 Silicone/Neoprene
- Source: Barcelona et al., 1983
- \* Trademark of DuPont



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## ATTACHMENT B

### COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive—may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings—pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

\* See also Attachment A.

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**ATTACHMENT C**



BORING NO. \_\_\_\_\_

**OVERBURDEN  
MONITORING WELL SHEET**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

**GROUND ELEVATION** \_\_\_\_\_

ELEVATION OF TOP OF SURFACE CASING: \_\_\_\_\_

ELEVATION OF TOP OF RISER PIPE: \_\_\_\_\_

STICK - UP TOP OF SURFACE CASING: \_\_\_\_\_

STICK - UP RISER PIPE: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF SURFACE CASING: \_\_\_\_\_

TYPE OF SURFACE CASING: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

BOREHOLE DIAMETER: \_\_\_\_\_

TYPE OF BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

DEPTH TOP OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

SLOT SIZE x LENGTH: \_\_\_\_\_

I.D. OF SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_

TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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PAGE TWO



BORING NO.: \_\_\_\_\_

### CONFINING LAYER MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION

CONFINING LAYER

ELEVATION OF TOP OF PERM. CASING : \_\_\_\_\_

ELEVATION OF TOP OF RISER PIPE: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF PERM. CASING: \_\_\_\_\_

TYPE OF SURFACE CASING: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

BOREHOLE DIAMETER: \_\_\_\_\_

PERM. CASING I.D. \_\_\_\_\_

TYPE OF CASING & BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP CONFINING LAYER: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF CASING: \_\_\_\_\_

ELEVATION / DEPTH BOT. CONFINING LAYER: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

DEPTH TOP OF SAND PACK: \_\_\_\_\_

ELEVATION/DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

BOREHOLE DIA. BELOW CASING: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_

TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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**ATTACHMENT C  
PAGE THREE**



**BEDROCK  
MONITORING WELL SHEET  
OPEN HOLE WELL**

BORING NO.: \_\_\_\_\_

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION \_\_\_\_\_

ELEVATION OF TOP OF CASING: \_\_\_\_\_

STICK UP OF CASING ABOVE GROUND SURFACE: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF CASING: \_\_\_\_\_

TYPE OF CASING: \_\_\_\_\_

TEMP. / PERM.: \_\_\_\_\_

DIAMETER OF HOLE: \_\_\_\_\_

TYPE OF CASING SEAL: \_\_\_\_\_

DEPTH TO TOP OF ROCK: \_\_\_\_\_

DEPTH TO BOTTOM CASING: \_\_\_\_\_

DIAMETER OF HOLE IN BEDROCK: \_\_\_\_\_

DESCRIBE IF CORE / REAMED WITH BIT:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

DESCRIBE JOINTS IN BEDROCK AND DEPTH:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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BORING NO.: \_\_\_\_\_

**BEDROCK  
MONITORING WELL SHEET  
WELL INSTALLED IN BEDROCK**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

ELEVATION OF TOP OF SURFACE CASING: \_\_\_\_\_  
 ELEVATION OF TOP OF RISER PIPE: \_\_\_\_\_  
 ELEVATION TOP OF PERM. CASING: \_\_\_\_\_  
 TYPE OF SURFACE SEAL: \_\_\_\_\_  
 I.D. OF SURFACE CASING: \_\_\_\_\_  
 TYPE OF SURFACE CASING: \_\_\_\_\_  
 \_\_\_\_\_  
 RISER PIPE I.D. \_\_\_\_\_  
 TYPE OF RISER PIPE: \_\_\_\_\_  
 \_\_\_\_\_  
 BOREHOLE DIAMETER: \_\_\_\_\_  
 PERM CASING I.D. \_\_\_\_\_  
 TYPE OF CASING & BACKFILL: \_\_\_\_\_  
 \_\_\_\_\_  
 ELEVATION / DEPTH TO BEDROCK: \_\_\_\_\_  
 ELEVATION / DEPTH BOTTOM OF CASING: \_\_\_\_\_  
 \_\_\_\_\_  
 BOREHOLE DIA. BELOW CASING: \_\_\_\_\_  
 TYPE OF BACKFILL: \_\_\_\_\_  
 \_\_\_\_\_  
 ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_  
 TYPE OF SEAL: \_\_\_\_\_  
 \_\_\_\_\_  
 ELEVATION / DEPTH TOP OF SAND PACK: \_\_\_\_\_  
 ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_  
 TYPE OF SCREEN: \_\_\_\_\_  
 \_\_\_\_\_  
 TYPE OF SAND PACK: \_\_\_\_\_  
 \_\_\_\_\_  
 ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_  
 ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_  
 TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_  
 \_\_\_\_\_  
 ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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**BEDROCK  
MONITORING WELL SHEET  
WELL INSTALLED IN BEDROCK**

BORING NO. \_\_\_\_\_

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

**GROUND ELEVATION**

ELEVATION OF TOP OF SURFACE CASING. \_\_\_\_\_

STICK UP OF CASING ABOVE GROUND SURFACE: \_\_\_\_\_

ELEVATION TOP OF RISER: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF SURFACE CASING: \_\_\_\_\_

DIAMETER OF HOLE: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

TYPE OF BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF BEDROCK: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SAND: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

SLOT SIZE & LENGTH: \_\_\_\_\_

I.D. SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

DIAMETER OF HOLE IN BEDROCK: \_\_\_\_\_

CORE / REAM: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF HOLE: \_\_\_\_\_

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## 1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

## 2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

## 5.0 PROCEDURES

### 5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

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1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
  - A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.
  - The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

## 5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.
- Pumps
  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.



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- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.
- Pails - Plastic, graduated.
- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

### 5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons ( $V = 0.163Tr^2$ ).

where:

V = Static volume of well in gallons.  
T = Thickness of water table in the well measured in feet, i.e., linear feet of static water.  
r = Inside radius of well casing in inches.  
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

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#### 5.4 EVACUATION OF STATIC WATER (PURGING)

##### 5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

##### 5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

###### 5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

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#### 5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

#### 5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

#### 5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

### 5.5 SAMPLING

#### 5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

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- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Working schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

#### 5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.
6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.
7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.
8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.
9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer).

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Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.
12. Add preservative if required. Label, tag, and number the sample bottle(s).
13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.
14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.
15. Decontaminate all equipment

#### **5.5.3 Sample Containers**

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

#### **5.5.4 Preservation of Samples and Sample Volume Requirements**

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

#### **5.5.5 Handling and Transporting Samples**

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

#### **5.5.6 Sample Holding Times**

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

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## 5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

## 5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

## 6.0 REFERENCES

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## 7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet  
Attachment B - Purging Equipment Selection

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**ATTACHMENT A  
SAMPLE LOG SHEET**



**SAMPLE LOG SHEET**

- ☐ Monitoring Well Data  
☐ Domestic Well Data  
☐ Other \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_

Case # \_\_\_\_\_

By \_\_\_\_\_

Project Site Name \_\_\_\_\_ Project Site Number \_\_\_\_\_  
 NUS Source No. \_\_\_\_\_ Source Location \_\_\_\_\_

Total Well Depth:		Purge Data			
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					
Signature(s):	Observations / Notes:				
Type of Sample <input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab - Composite					
Analysis:	Preservative	Organic		Inorganic	
		Traffic Report #			
		Tag #			
		AB #			
		Date Shipped			
		Time Shipped			
		Lab			
		Volume			



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ATTACHMENT B  
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
<u>1.25-inch</u>								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
<u>2-inch</u>								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
<u>4-inch</u>								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
<u>6-inch</u>								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
<u>8-inch</u>								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	dedicated; gas drive (positive displacement)	1 5/16	PE, brass, nylon, aluminum oxide	0-150 with sid tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	< 1 0/NA	(not submersible) Tygon® silicone Viton®	0-30	670 mL/min with 7015- 20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	< 1 5/8 < 2 0/NA	PP, PE, PVC, SS, Teflon®, Tefast®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors avail- able; must be primed
Gastek Corp.	Baker 219-4	portable; grab (positive dis- placement)	1 65/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1 5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysis, Inc. (IEA)	Aquarius	portable; bladder (positive dis- placement)	1 75/43	SS, Teflon®, Viton®	0-280	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive dis- placement)	1 75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Special- ties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive dis- placement)	1 75/50	PC, silicone, Teflon®, PP, PE, Delrin®, acetal	0-150	0-7500 mL/min	998	requires compressed gas (40 psi minimum)
Kech Geophysical Instruments, Inc.	SP-81 Submer- sible Sampling Pump	portable; helical rotor (positive displacement)	1 75/26	SS, Teflon®, PP, EPDM, Viton®	0-150	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive dis- placement)	1 75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive dis- placement)	1 75/12	acrylic, Delrin®	no limit	app. 250 mL	125-180	other materials and models available; for measuring thick- ness of "floating" contaminants
Q E D Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive dis- placement)	1 66/36	PVC	0-230	0-7000 mL/min	300-400	requires compressed gas; piezometric level indi- cator; other materials available

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Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co	Model 500 Vari Flow Pump	portable; per- static (suction)	<0.5/N/A	(not submersible) rubber, Tygon® or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selec- ted, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive dis- placement)	1.8/22	SS, Teflon®, Del- rin®, PP, Viton®, acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flush- ing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedi- cated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive dis- placement)	1.8/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive dis- placement)	1.68/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; op- tional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flush- ing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tote Devices Co.	Sampling Pump	portable; bladder (positive dis- placement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas re- quired; DC control module; custom built

## Construction Materials Abbreviations

PE Polyethylene  
PP Polypropylene  
PVC Polyvinyl Chloride  
SS Stainless Steel  
PC Polycarbonate  
EPDM Ethylene-Propylene Diene  
(synthetic rubber)

## Other Abbreviations

NA Not Applicable  
AC Alternating Current  
DC Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

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#### 4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

#### 5.0 PROCEDURES

##### 5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

##### 5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

###### 5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

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- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

#### 5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

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- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).
- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

### **5.3 CHAIN-OF-CUSTODY PROCEDURES**

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

#### **5.3.1 Field Custody Procedures**

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

#### **5.3.2 Transfer of Custody and Shipment**

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name — project name can be obtained from the Sampling Plan).
- Sign, date, and enter the time under "Relinquished by" entry.

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- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

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### 5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

### 6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

### 7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I  
Attachment B - Chain-of-Custody Record Form for use in Region II  
Attachment C - Chain-of-Custody Record Form for use in Region III  
Attachment D - Chain-of-Custody Record Form for use in Region IV  
Attachment E - Sample Label  
Attachment F - Sample Identification Tag  
Attachment G - Chain-of-Custody Seal



**REMARKS**[illegible]

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**ATTACHMENT B**  
**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II**  
 (Original is 8 by 10-1/2)  
**CHAIN OF CUSTODY RECORD**

ENVIRONMENTAL PROTECTION AGENCY - REGION II  
 SURVEILLANCE & ANALYSIS DIVISION  
 BRISOL, NEW JERSEY 08807

Name of Unit and Address						
Sample Number	Number of Containers	Description of Samples				
Person Assuming Responsibility for Samples					Time	Date
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	

**ATTACHMENT C**  
**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III**  
**(Original is 8-1/2 x 11-3/4")**

**REGION 3**  
Curie Bldg., 6th & Walnut Sts.  
Philadelphia, Pennsylvania 19106

**ENVIRONMENTAL PROTECTION AGENCY**  
**Office of Enforcement**

[illegible]

**3-15966**

## SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY

Number

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**Effective Date**

05/04/90

U S ENVIRONMENTAL PROTECTION AGENCY  
REGION 4

### CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION  
COLLEGE STATION ROAD  
ATHENS, GEORGIA 30613

**ATTACHMENT D**  
**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV**

**(Original is 8-1/2 by 14)**

[illegible]

**DISTRIBUTION:** Original and Pink copies accompanying sample shipment to laboratory. Pink copy retained by laboratory. Yellow copy retained by sampler (Blue copy only a copy as needed).

**№ 4 3526**

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**ATTACHMENT E  
SAMPLE LABEL**

<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <b>NUM</b> PROJECT: _____ <small>COMPOSITION</small>	
STATION LOCATION: _____	
DATE: ____/____/____ TIME: _____ hrs.	
MEDIA: WATER <input type="checkbox"/> SOIL <input type="checkbox"/> SEDIMENT <input type="checkbox"/> _____ <input type="checkbox"/>	
CONCENTRATION: LOW <input type="checkbox"/> MED <input type="checkbox"/> HIGH <input type="checkbox"/>	
TYPE: GRAB <input type="checkbox"/> COMPOSITE <input type="checkbox"/>	
ANALYSIS	
VOA <input type="checkbox"/> BNA's <input type="checkbox"/>	PRESERVATION Cool to 4°C <input type="checkbox"/> HNO <sub>3</sub> to pH <2 <input type="checkbox"/> NaOH to pH >12 <input type="checkbox"/> _____ <input type="checkbox"/>
PCB's <input type="checkbox"/> PESTICIDES <input type="checkbox"/>	
METALS: TOTAL <input type="checkbox"/> DISSOLVED <input type="checkbox"/>	
CYANIDE <input type="checkbox"/>	
_____ <input type="checkbox"/> Sampled by: _____ Case No.: _____ Traffic Report No.: _____ Remarks: _____	

ACTILE: FORMS\807LAB

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**ATTACHMENT F  
SAMPLE IDENTIFICATION TAG**



☆ GPO 505-552



Designate:	Grab	Preservative: Yes <input type="checkbox"/> No <input type="checkbox"/>																																											
	Comp																																												
Time	Signatures	<b>ANALYSES</b>																																											
		<table border="1"> <tr> <td>BOD</td> <td>Anions</td> <td></td> </tr> <tr> <td>Solids</td> <td>(TSS) (TDS) (SS)</td> <td></td> </tr> <tr> <td>COD, TOC, Nutrients</td> <td></td> <td></td> </tr> <tr> <td>Phenolics</td> <td></td> <td></td> </tr> <tr> <td>Mercury</td> <td></td> <td></td> </tr> <tr> <td>Metals</td> <td></td> <td></td> </tr> <tr> <td>Cyanide</td> <td></td> <td></td> </tr> <tr> <td>Oil and Grease</td> <td></td> <td></td> </tr> <tr> <td>Organics GC/MS</td> <td></td> <td></td> </tr> <tr> <td>Priority Pollutants</td> <td></td> <td></td> </tr> <tr> <td>Volatile Organics</td> <td></td> <td></td> </tr> <tr> <td>Pesticides</td> <td></td> <td></td> </tr> <tr> <td>Mutagenicity</td> <td></td> <td></td> </tr> <tr> <td>Bacteriology</td> <td></td> <td></td> </tr> <tr> <td>Remarks:</td> <td colspan="2"></td> </tr> </table>	BOD	Anions		Solids	(TSS) (TDS) (SS)		COD, TOC, Nutrients			Phenolics			Mercury			Metals			Cyanide			Oil and Grease			Organics GC/MS			Priority Pollutants			Volatile Organics			Pesticides			Mutagenicity			Bacteriology			Remarks:
BOD	Anions																																												
Solids	(TSS) (TDS) (SS)																																												
COD, TOC, Nutrients																																													
Phenolics																																													
Mercury																																													
Metals																																													
Cyanide																																													
Oil and Grease																																													
Organics GC/MS																																													
Priority Pollutants																																													
Volatile Organics																																													
Pesticides																																													
Mutagenicity																																													
Bacteriology																																													
Remarks:																																													
Month/Day/Year	Station Location	Tag No.																																											
Station No.		3 60966																																											
Project Code		Lab Sample No.																																											

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



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ATTACHMENT G  
CHAIN-OF-CUSTODY SEAL

<b>Signature</b>			<b>CUSTODY SEAL</b>
<b>Date</b>			<b>Date</b>
<b>CUSTODY SEAL</b>			<b>Signature</b>

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**Reportable Quantity (RQ)** - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to §171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

#### 4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

#### 5.0 PROCEDURES

##### 5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

##### 5.2 ENVIRONMENTAL SAMPLES

###### 5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.



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- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

#### **5.2.2    Marking Labeling**

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

#### **5.2.3    Shipping Papers**

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

#### **5.2.4    Transportation**

There are no DOT restrictions on mode of transportation.

### **5.3       DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES**

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

#### **5.3.1    Known Substances**

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . .

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2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .
3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .
4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . .
5. You will have to go to the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

### 5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however, all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

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## 5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

### 5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.
2. Complete sample label and sample identification tag and attach securely to sample container.
3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.
4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.
5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

### 5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):
  - Laboratory name and address.
  - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:
  - Proper shipping name.
  - UN or NA number.
  - Proper label(s).
  - Addressee and sender.

Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

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#### 5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).
  - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
  - "Limited Quantity" (or "Ltd. Qty.").
  - "Cargo Aircraft Only."
  - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
  - "Laboratory Samples" (if applicable).
2. Include Chain-of-Custody Record, properly executed in outside container.
3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

#### 5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.
2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

#### 6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CFR 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

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## 7.0 ATTACHMENTS

- Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
- Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
- Attachment C - Hazardous Materials Shipping Checklist
- Attachment D - Standard Industry Certification Form

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### **ATTACHMENT A**

#### **DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)**

1. **Radioactive material (except a limited quantity)**
2. **Poison A**
3. **Flammable gas**
4. **Nonflammable gas**
5. **Flammable liquid**
6. **Oxidizer**
7. **Flammable Solid**
8. **Corrosive material (liquid)**
9. **Poison B**
10. **Corrosive material (solid)**
11. **Irritating material**
12. **Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])**
13. **ORM-B**
14. **ORM-A**
15. **Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)**
16. **ORM-E**

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### ATTACHMENT B

#### DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable, nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	---
Grenade (with Poison "A" gas charge)	---
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

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## ATTACHMENT C HAZARDOUS MATERIALS SHIPPING CHECKLIST

### PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

### SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

### RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.





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## 1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

## 2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

## 3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

## 4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

## 5.0 PROCEDURES

### 5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

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- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

## 5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

## 6.0 REFERENCES

None.

## 7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

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**ATTACHMENT A  
TYPICAL SITE LOGBOOK ENTRY**

START TIME: \_\_\_\_\_ DATE: \_\_\_\_\_

SITE LEADER: \_\_\_\_\_

PERSONNEL: \_\_\_\_\_

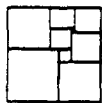
NUS	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

**ACTIVITIES:**

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well \_\_\_\_\_ resumes. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well \_\_\_\_\_.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well \_\_\_\_\_.
4. Well \_\_\_\_\_ drilled. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 2, page \_\_\_\_\_ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well \_\_\_\_\_ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on-site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit \_\_\_\_\_.
8. Test pit \_\_\_\_\_ dug with cuttings placed in dump truck. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit \_\_\_\_\_ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

\_\_\_\_\_  
Field Operations Leader



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

## **STANDARD OPERATING PROCEDURES**

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Revision  
2

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
D. Senovich

Subject

FORMS USED IN RI ACTIVITIES

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## 1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

## 2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of.

## 3.0 GLOSSARY

Controlled Document - A consecutively-numbered form released by EPA for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

## 4.0 RESPONSIBILITIES

Field Operations Leader - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test forms (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

## 5.0 PROCEDURES

### 5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

#### 5.1.1 Sample Label

The sample label is a 2-by 4-inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1.

#### 5.1.2 Sample Identification Tag

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

#### 5.1.3 Chain-of-Custody Record Form

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in Zone 1 uses a

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slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. Chain-of-custody record forms for Regions I, II, and IV are illustrated in SA-6.1 as well as procedures for filling out forms.

#### **5.1.4 Chain-of-Custody Seal**

Attachment B-4 is an example of a custody seal. The Custody seal is a 1-by 3-inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

#### **5.1.5 Bottle Delivery Order (DO) Form**

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

#### **5.1.6 Repository Packing List (PL) Form**

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

#### **5.1.8 Sample Log Sheet**

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

#### **5.1.9 Traffic Reports (for CLP Laboratory Analyses)**

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

#### **5.1.10 Traffic Report Label**

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

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#### 5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

#### 5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

#### 5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

### 5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

#### 5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

#### 5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

#### 5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

#### 5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.



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### 5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

### 5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

### 5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

## 5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

### 5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

## 6.0 REFERENCES

None.

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## 7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations  
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 Attachment B-2 - Sample Identification Tag  
 Attachment B-3 - Chain-of-Custody Record From, Region III  
 Attachment B-4 - Chain-of-Custody Seal  
 Attachment B-5 - CLP Sample Bottle Repository Order Form  
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 Attachment B-7 - Groundwater Sample Log Sheet Form  
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 Attachment C-5 - Summary Log of Boring  
 Attachment C-6 - Overburden Monitoring Well Construction Sheet  
 Attachment C-7 - Confining Layer Monitoring Well Construction Sheet  
 Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet  
 Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet  
 Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet  
 Attachment C-11 - Test Pit Log Form  
 Attachment D-1 - Equipment Calibration Log

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## ATTACHMENT A


### TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP Number	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
B-5	CLP Sample Bottle Repository Form	SA-6.6	Required
B-6	Repository Packing List Form	SA-6.6	Required
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
B-9	Surface Water Sample Log Sheet	SA-6.6	Required
B-10	Container Sample Log Sheet	SA-6.6	Required
B-11	Organics Traffic Report Form	SA-6.6	Controlled
B-12	Inorganics Traffic Report Form	SA-6.6	Controlled
B-13	Traffic Report Labels	SA-6.6	Controlled
B-14	Special Analytical Services (SAS) Packing List	SA-6.6	Required
B-15	Dioxin Shipment Record Form	SA-6.6	Required
B-16	Sample Shipping Log	SA-6.4	Required
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
C-2	Pumping Test Data Sheet	GH-2.3	Required
C-3	Hydraulic Conductivity Testing Data Sheet	GH-2.4	Required
C-4	Packer Testing Report Form	GH-2.2	Required
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
C-7	Confining Layer Monitoring Well Construction Sheet	GH-1.5	Required
C-8	Bedrock (Open Hole) Monitoring Well Construction Sheet	GH-1.5	Required
C-9	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-10	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-11	Test Pit Log	GH-1.8	Required
D-1	Equipment Calibration Log	----	Required

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ATTACHMENT B-1

SAMPLE LABEL

 PROJECT: _____	
STATION LOCATION: _____	
DATE: ____/____/____ TIME: _____ hrs.	
MEDIA: WATER <input type="checkbox"/> SOIL <input type="checkbox"/> SEDIMENT <input type="checkbox"/>	
CONCENTRATION: LOW <input type="checkbox"/> MED <input type="checkbox"/> HIGH <input type="checkbox"/>	
TYPE: GRAB <input type="checkbox"/> COMPOSITE <input type="checkbox"/>	
ANALYSIS	PRESERVATION
VOA <input type="checkbox"/> BNA's <input type="checkbox"/>	Cool to 4°C <input type="checkbox"/>
PCB's <input type="checkbox"/> PESTICIDES <input type="checkbox"/>	HNO <sub>3</sub> to pH <2 <input type="checkbox"/>
METALS: TOTAL <input type="checkbox"/> DISSOLVED <input type="checkbox"/>	NAOH to pH>12 <input type="checkbox"/>
CYANIDE <input type="checkbox"/>	_____ <input type="checkbox"/>
Sampled by: _____	
Case No.: _____ Traffic Report No.: _____	
Remarks:	

ACTLE: FORMS\BOTLABL

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**ATTACHMENT B-2**  
**SAMPLE IDENTIFICATION TAG**

☆ GPO 506-552

Designate:	Grab	Preservative: Yes <input type="checkbox"/> No <input type="checkbox"/>																																								
	Comp.																																									
Time	Samplers (Signatures)	<b>ANALYSES</b>																																								
		<table border="1"> <tr> <td>BOD</td> <td>Anions</td> <td></td> </tr> <tr> <td>Solids</td> <td>(TSS) (TDS) (SS)</td> <td></td> </tr> <tr> <td colspan="2">COD, TOC, Nutrients</td> <td></td> </tr> <tr> <td colspan="2">Phenolics</td> <td></td> </tr> <tr> <td colspan="2">Mercury</td> <td></td> </tr> <tr> <td colspan="2">Metals</td> <td></td> </tr> <tr> <td colspan="2">Cyanide</td> <td></td> </tr> <tr> <td colspan="2">Oil and Grease</td> <td></td> </tr> <tr> <td colspan="2">Organics GC/MS</td> <td></td> </tr> <tr> <td colspan="2">Priority Pollutants</td> <td></td> </tr> <tr> <td colspan="2">Volatile Organics</td> <td></td> </tr> <tr> <td colspan="2">Pesticides</td> <td></td> </tr> <tr> <td colspan="2">Mutagenicity</td> <td></td> </tr> <tr> <td colspan="2">Bacteriology</td> <td></td> </tr> </table>	BOD	Anions		Solids	(TSS) (TDS) (SS)		COD, TOC, Nutrients			Phenolics			Mercury			Metals			Cyanide			Oil and Grease			Organics GC/MS			Priority Pollutants			Volatile Organics			Pesticides			Mutagenicity			Bacteriology
BOD	Anions																																									
Solids	(TSS) (TDS) (SS)																																									
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Oil and Grease																																										
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Priority Pollutants																																										
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Pesticides																																										
Mutagenicity																																										
Bacteriology																																										
Month/Day/Year	Station Location	Remarks:																																								
Station No.																																										
Project Code	Tag No.	Lab Sample No.																																								
	3 60966																																									

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III**  
(Original is 8-1/2 x 11-3/4")

**Curtis Bldg., 6th & Walnut Sts.  
Philadelphia, Pennsylvania 19106**

**ENVIRONMENTAL PROTECTION AGENCY**  
**Office of Enforcement**



[illegible]

3-15966

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ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

_____ Signature			<b>CUSTODY SEAL</b>
_____ Date			_____ Date
<b>CUSTODY SEAL</b>			_____ Signature

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**ATTACHMENT B-5  
CLP SAMPLE BOTTLE REPOSITORY  
SUPERFUND DELIVERY REQUEST**

**REQUEST NO.** \_\_\_\_\_

Date of Request: \_\_\_\_\_

Type of Request:

Routine [ ] \_\_\_\_\_

Fast Turnaround [ ] \_\_\_\_\_

Emergency [ ] \_\_\_\_\_

(Date/Time request called in)

From (Name): \_\_\_\_\_

Affiliation: \_\_\_\_\_

Telephone: \_\_\_\_\_

AR Signature: \_\_\_\_\_

TO: I-Chem Research Corporation  
23787-F Eichler Street  
Hayward, CA 94545  
Phone: 415/782/3095

Ship the following items for arrival by: \_\_\_\_\_ (Date)  
(If applicable) Ship to arrive no earlier than: \_\_\_\_\_ (Date)

Item		Description	No. of Items Per Case	No. of Cases Requested
A	80-oz.	amber glass bottle	6	
B	40-ml	glass vial	72	
C	1-liter	polyethylene bottle	12	
D	120-ml	wide-mouth glass vial	12	
E	1-oz.	wide-mouth glass jar	12	
F	8-oz.	wide-mouth glass jar	12	
G	4-oz.	wide-mouth glass jar	12	
H	1-liter	amber glass bottle	12	
J	32-oz.	wide-mouth glass jar	12	
K	4-liter	amber glass bottle	4	
L	500-ml	polyethylene bottle	24	

Ship To: \_\_\_\_\_  
(Provide street address) \_\_\_\_\_  
Attention: \_\_\_\_\_  
Call before delivery: \_\_\_\_\_  
(Phone No.): \_\_\_\_\_

**DISTRIBUTION:**      *White-Repository*      *Yellow-Requestor*      *Pink-SMO*



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### ATTACHMENT B-6

#### CLP SAMPLE BOTTLE REPOSITORY SUPERFUND PACKING LIST

#### REPOSITORY

I-Chem Research Corporation  
23787-F Eichler Street  
Hayward, CA 94545  
Phone: 415/782-3905

DELIVERY REQUEST NO. \_\_\_\_\_

Request date: \_\_\_\_\_

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: \_\_\_\_\_

#### DESTINATION (from Delivery Request)

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone No: \_\_\_\_\_

The materials listed below have been shipped as requested.

Date Shipped: \_\_\_\_\_

Mode of Shipment: \_\_\_\_\_

Shipment ID No: \_\_\_\_\_

Signature: \_\_\_\_\_

Type of Shipment: ☐ Complete ☐ Partial ☐ Partial/Completes Request

Item No.	Description	No. of Cases Shipped	Lot Number(s)	QC Clearance Number(s)
A	80-oz glass	_____	_____	_____
B	40-mL glass	_____	_____	_____
C	1-L poly	_____	_____	_____
D	120-mL glass	_____	_____	_____
E	16-oz glass	_____	_____	_____
F	8-oz glass	_____	_____	_____
G	4-oz glass	_____	_____	_____
H	1-L glass	_____	_____	_____
J	32-oz glass	_____	_____	_____
K	4-L glass	_____	_____	_____
L	500-mL poly	_____	_____	_____

#### —AUTHORIZED REQUESTOR USE ONLY—

Sign below and forward the yellow copy to the Sample Management Office (SMO) within 7 days of shipment receipt. Keep the pink copy for your file.

The above request was received by the designee, inspected, and accepted.

Date of Receipt: \_\_\_\_\_ Requestor Signature: \_\_\_\_\_

Send yellow copy to: USEPA Sample Management Office  
P.O. Box 818  
Alexandria, VA 22313

**DISTRIBUTION:** White—Shipment Designee  
Blue—Shipping Contractor  
Green—SMO

Yellow—Requestor (for return to SMO)  
Pink—Requestor  
Gold—Repository

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**ATTACHMENT B-7**



**SAMPLE LOG SHEET**

- ☐ Monitoring Well Data  
☐ Domestic Well Data  
☐ Other \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Case # \_\_\_\_\_

By \_\_\_\_\_

Project Site Name \_\_\_\_\_ Project Site Number \_\_\_\_\_  
 NUS Source No. \_\_\_\_\_ Source Location \_\_\_\_\_

Total Well Depth:		Purge Data				
Well Casing Size & Depth:		Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:						
One Casing Volume:						
Start Purge (hrs.):						
End Purge (hrs.):						
Total Purge Time (min.):						
Total Amount Purged (gal.):						
Monitor Reading:						
Purge Method:						
Sample Method:						
Depth Sampled:						
Sample Date & Time:		Sample Data				
		pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:						
Signature(s):	Observations / Notes:					
Type of Sample <input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab - Composite						
Analysis:	Preservative		Organic	Inorganic		
		Traffic Report #				
		Tag #				
		AS #				
		Date Shipped				
		Time Shipped				
		Lab				
		Volume				





Subject

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## ATTACHMENT B-10



## SAMPLE LOG SHEET

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Container Data

Case # \_\_\_\_\_

By \_\_\_\_\_

Project Site Name \_\_\_\_\_ Project Site Number \_\_\_\_\_  
 NUS Source No. \_\_\_\_\_ Source Location \_\_\_\_\_

Container Source	Container Description		
<input type="checkbox"/> Drum <input type="checkbox"/> Bung Top <input type="checkbox"/> Lever Lock <input type="checkbox"/> Bolted Ring <input type="checkbox"/> Other _____  <input type="checkbox"/> Bag / Sack <input type="checkbox"/> Tank <input type="checkbox"/> Other _____	Color _____ Condition _____ Markings _____ Vol. of Contents _____ Other _____		
Disposition of Sample	Sample Description		
<input type="checkbox"/> Container Sampled <input type="checkbox"/> Container opened but not sampled. Reason _____  Container not opened. Reason _____	Layer 1 Phase <input type="checkbox"/> Sol. <input type="checkbox"/> Liq. Color _____ Viscosity <input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H % of Total _____ Volume _____ Other _____	Layer 2 Phase <input type="checkbox"/> Sol. <input type="checkbox"/> Liq. Color _____ Viscosity <input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H % of Total _____ Volume _____ Other _____	Layer 3 Phase <input type="checkbox"/> Sol. <input type="checkbox"/> Liq. Color _____ Viscosity <input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H % of Total _____ Volume _____ Other _____
Monitor Reading:	Type of Sample		
Sample Method:	<input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration		
Sample Date & Time:	<input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab - Composite		
		Organic	Inorganic
	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		



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### ATTACHMENT B-12

 USEPA CONTRACT LABORATORY PROGRAM SAMPLE MANAGEMENT OFFICE P.O. BOX 818 ALEXANDRIA, VA 22313 703/557-2490 FTS-557-2490	CASE NO:	SAS NO: (IF APPLICABLE)
	<b>INORGANIC TRAFFIC REPORT</b> <small>(FOR CLP USE ONLY)</small>	

TYPE OF ACTIVITY (CIRCLE ONE) ① SUPERFUND—PA SI ESI RIFS RD RA ER NPLD O&M OTHER _____ NON-SUPERFUND—_____ PROGRAM  SITE NAME: _____  CITY, STATE: _____ SITE SPILL ID: _____  REGION NO: _____ SAMPLING COMPANY ② _____ SAMPLER (NAME) _____	SHIP TO: _____ ③  ATTN: _____  SAMPLING DATE: _____ ④ BEGIN: _____ END: _____ DATE SHIPPED: _____ CARRIER: _____ ⑤ AIRBILL NO: _____	SAMPLE DESCRIPTION ⑥ (ENTER IN BOX A) 1. SURFACE WATER 4. SOIL 2. GROUND WATER 5. SEDIMENT 3. LEACHATE 6. OIL (SAS) 7. WASTE (SAS)  DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE  SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS  SEE REVERSE FOR ADDITIONAL INSTRUCTIONS
---	---	---

CLP SAMPLE NUMBER (FROM LABELS)	② SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7							⑦ RAS ANALYSIS						⑧ SPECIAL HANDLING	⑨ STATION LOCATION	
	⑤ CONCENTRATION L - LOW M - MED H - HIGH (SAS)							TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS)					
											SULFIDE	PH	CONDUC- TIVITY	DECATS		

Subject <b>FORMS USED IN RI ACTIVITIES</b>	Number <b>SA-6.4</b>	Page <b>20 of 36</b>
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**ATTACHMENT B-13**  
**TRAFFIC REPORT LABELS**

**MAB 342**

**3 6003**

**AC 865** - **Soil/Sediment**  
**(VOA)**



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**ATTACHMENT B-14**

**U.S. ENVIRONMENTAL PROTECTION AGENCY**  
**CLP Sample Management Office**  
**P.O. Box 818 - Alexandria, Virginia 22313**  
**Phone: 703/557-2490 - FTS/557-2490**

**SAS Number**

**SPECIAL ANALYTICAL SERVICE  
PACKING LIST**

<b>Sampling Office:</b> _____	<b>Sampling Date(s):</b> _____	<b>Ship To:</b>     <b>Attn:</b>	<b>For Lab Use Only</b>
<b>Sampling Contact:</b> _____	<b>Date Shipped:</b> _____		<b>Date Samples Rec'd:</b> _____
<b>(name)</b>	<b>Site Name/Code:</b> _____		<b>Received By:</b> _____
<b>(phone)</b>	_____		_____

Sample Numbers	Sample Description i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____
11. _____	_____	_____
12. _____	_____	_____
13. _____	_____	_____
14. _____	_____	_____
15. _____	_____	_____
16. _____	_____	_____
17. _____	_____	_____
18. _____	_____	_____
19. _____	_____	_____
20. _____	_____	_____

**For Lab Use Only**

**White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy**



page      of      EPA SAMPLE SHIPPING LOG FOR ALL SAMPLES SENT THROUGH THE CONTRACT LAB PROGRAM (12/85 version)

**SAS REQUEST: (details required)**

**Phase:**

[illegible]

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### ATTACHMENT C-1

### GROUNDWATER LEVEL MEASUREMENT SHEET

#### LOCATION

Project Name: \_\_\_\_\_  
 Project No.: \_\_\_\_\_  
 Personnel: \_\_\_\_\_  
 Date: \_\_\_\_\_

Municipality: \_\_\_\_\_  
 County: \_\_\_\_\_  
 State: \_\_\_\_\_  
 Street or  
 Map Location \_\_\_\_\_  
 (If Off-Site)

#### WEATHER CONDITIONS

Temperature Range: \_\_\_\_\_  
 Precipitation: \_\_\_\_\_  
 Barometric Pressure: \_\_\_\_\_

Equipment No.: \_\_\_\_\_  
 Equipment Name: \_\_\_\_\_  
 Latest Calibration Date: \_\_\_\_\_

Tidally-Influenced: [ ] Yes

[ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

\* All elevations to nearest 0.01 foot.





# **PACKER TESTING REPORT FORM**

~~PROJECT:  
BORING NO.:  
TEST INTERVAL:~~

**CASING DEPTH:**

## PACKER TEST REPORT

PROJECT NO.:  
CONTRACTOR:  
BY: \_\_\_\_\_

**TEST NO:**

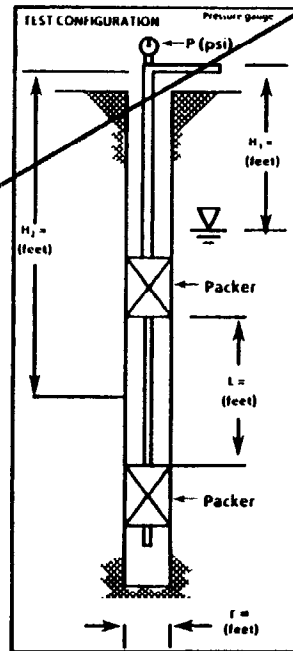
**CHECKED:**

PAGE \_\_\_\_\_ OF \_\_\_\_\_  
 STATIC WATER LEVEL \_\_\_\_\_  
 PACKER PRESSURE \_\_\_\_\_

[illegible]

CP =  $(1/(2 \times L)) \ln(L/r)$  (70,315.5)  
7.48 Gallons = 1 ft<sup>3</sup>  
1 psi = 2.31 ft head  
Remarks: \_\_\_\_\_

$H_1$  is used when the test length is below the water table  
 $H_2$  is used when the test length is above the water table



Length of test beam in feet	CP Drilling Bit Size			
	1/8 (1.5")	3/16 (1.875")	1/4 (2.375")	5/16 (3")
1	15,000	20,500	25,000	23,500
2	19,000	26,000	30,000	25,500
3	9,000	9,000	8,000	8,000
5	6,000	6,500	6,000	5,000
10	5,000	5,000	5,000	6,000
15	4,000	3,000	3,000	3,000
20	3,500	3,000	3,000	2,000





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**ATTACHMENT C-5  
(CONTINUED)**

## SOIL TERMS

## UNIFIED SOIL CLASSIFICATION (USCS)

UNIFIED SOIL CLASSIFICATION (USCS)										
COARSE GRAINED SOILS More than half of material is LARGER than No. 200 sieve size					FINE GRAINED SOILS More than half of material is SMALLER than No. 200 sieve size					
FIELD IDENTIFICATION PROCEDURES (Including particles larger than 3" & basing fractions on estimated weights)			GROUP SYM-BOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Including particles larger than 3" & basing fractions on estimated weights)			GROUP SYM-BOL	TYPICAL NAMES	
GRAVELS 50% (+) > 3" Ø	CLEAN GRAVELS w/ fines Low % Less %	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravel, gravel sand mixtures, little or no fines.	Identification procedures on fraction smaller than No. 40 sieve size					
		Prepredominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravel, gravel sand mixtures, little or no fines.	SILTS & CLAYS Liquid limit < 50	DRY STRENGTH (Crushing Characteristics)	PLASTICITY (Reaction to Shaking)	TOUGHNESS (Consistency Note Plastic Limit)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Non plastic fines (for identification procedures see M1)	GM	Silty gravel, poorly graded gravel sand silt mixtures.	None to slight		Quick to slow	None			
	Plastic fines (for identification procedures see (1))	GC	Clayey gravel, poorly graded gravel sand clay mixtures.	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.		
SANDS 50% (+) < 3" Ø	CLEAN SANDS w/ fines Low % Less %	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.	SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow	Slight	OL	Organic silts and organic silt clays of low plasticity.
		Prepredominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	Non plastic fines (for identification procedures see M1)	SM	Silty sands, poorly graded sand silt mixtures.	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays.		
	Plastic fines (for identification procedures see (1))	SC	Clayey sands, poorly graded sand clay mixtures.	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity.		
					HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.		PT	Peat and other organic soils.	

Boundary classifications both possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder. All names used on this chart are U.S. standard.

## DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE · BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

## CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

## ROCK TERMS

### ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks concussively (several blows) Sharp edges

## ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

### LEGEND

### SOIL SAMPLES - TYPES

- 5 - 2" O D Split Barrel Sample  
51 - 3" O D Unsplit Barrel Sample  
0 - Other Samples, Specify in Remarks

### ROCK SAMPLES - TYPES

- A NA (Conventional) Core (-) 1/8" O.D.  
Q mQ (Weldable) Core (-) 1/8" O.D.  
P Other Core Sizes, Specify in Remarks

### WATER LEVELS

- 12/18  
V 12.6" Initial Level = /Date & Dept
- 12/18  
V 12.6" Stabilized Level = /Date & Dept

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# ATTACHMENT C-6



BORING NO. \_\_\_\_\_

## OVERBURDEN MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION \_\_\_\_\_

ELEVATION OF TOP OF SURFACE CASING \_\_\_\_\_

ELEVATION OF TOP OF RISER PIPE \_\_\_\_\_

STICK - UP TOP OF SURFACE CASING \_\_\_\_\_

STICK - UP RISER PIPE \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF SURFACE CASING: \_\_\_\_\_

TYPE OF SURFACE CASING: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

BOREHOLE DIAMETER: \_\_\_\_\_

TYPE OF BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

DEPTH TOP OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

SLOT SIZE x LENGTH: \_\_\_\_\_

I.D. OF SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_

TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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# ATTACHMENT C-7



BORING NO.: \_\_\_\_\_

## CONFINING LAYER MONITORING WELL SHEET

11/5/87

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION

ELEVATION OF TOP OF PERM. CASING : \_\_\_\_\_

ELEVATION OF TOP OF RISER PIPE: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF PERM. CASING: \_\_\_\_\_

TYPE OF SURFACE CASING: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

BOREHOLE DIAMETER: \_\_\_\_\_

PERM. CASING I.D. \_\_\_\_\_

TYPE OF CASING & BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP CONFINING LAYER: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF CASING: \_\_\_\_\_

ELEVATION / DEPTH BOT. CONFINING LAYER: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

DEPTH TOP OF SAND PACK: \_\_\_\_\_

ELEVATION/DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

BOREHOLE DIA. BELOW CASING: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_

TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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### ATTACHMENT C-8



## BEDROCK MONITORING WELL SHEET OPEN HOLE WELL

BORING NO.: \_\_\_\_\_

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

ELEVATION OF TOP OF CASING: \_\_\_\_\_

STICK UP OF CASING ABOVE GROUND SURFACE: \_\_\_\_\_

GROUND ELEVATION \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF CASING: \_\_\_\_\_

TYPE OF CASING: \_\_\_\_\_

TEMP. / PERM.: \_\_\_\_\_

DIAMETER OF HOLE: \_\_\_\_\_

TYPE OF CASING SEAL: \_\_\_\_\_

DEPTH TO TOP OF ROCK: \_\_\_\_\_

DEPTH TO BOTTOM CASING: \_\_\_\_\_

DIAMETER OF HOLE IN BEDROCK: \_\_\_\_\_

DESCRIBE IF CORE / REAMED WITH BIT: \_\_\_\_\_

DESCRIBE JOINTS IN BEDROCK AND DEPTH: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

Subject

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## ATTACHMENT C-9

BORING NO.: \_\_\_\_\_

# **BEDROCK MONITORING WELL SHEET WELL INSTALLED IN BEDROCK**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION

ELEVATION OF TOP OF SURFACE CASING: \_\_\_\_\_

ELEVATION OF TOP OF RISER PIPE: \_\_\_\_\_

ELEVATION TOP OF PERM. CASING: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF SURFACE CASING: \_\_\_\_\_

TYPE OF SURFACE CASING: \_\_\_\_\_

RISER PIPE I.D. \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

BOREHOLE DIAMETER: \_\_\_\_\_

PERM. CASING I.D. \_\_\_\_\_

TYPE OF CASING & BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TO BEDROCK: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF CASING: \_\_\_\_\_

BOREHOLE DIA. BELOW CASING: \_\_\_\_\_

TYPE OF BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF SAND PACK: \_\_\_\_\_

TYPE OF BACKFILL BELOW OBSERVATION WELL: \_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

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**ATTACHMENT C-10**



**BEDROCK  
MONITORING WELL SHEET  
WELL INSTALLED IN BEDROCK**

BORING NO. \_\_\_\_\_

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

The diagram illustrates a vertical well installation. At the top, a 'STICK UP OF CASING ABOVE GROUND SURFACE' is shown. Below ground level, 'SURFACE CASING' is depicted with a 'TYPE OF SURFACE SEAL'. The 'DIAMETER OF HOLE' and 'RISER PIPE I.D.' are indicated. The well continues into the ground with 'TYPE OF BACKFILL'. A 'TOR' (Top of Rock) line is marked. Below this, a 'SEAL' is shown with 'ELEVATION / DEPTH TOP OF SEAL' and 'ELEVATION / DEPTH TOP OF BEDROCK'. Further down, a 'SAND' layer is indicated with 'ELEVATION / DEPTH TOP OF SAND'. A 'SCREEN' is located below the sand, with 'ELEVATION / DEPTH TOP OF SCREEN', 'TYPE OF SCREEN', and 'SLOT SIZE x LENGTH'. Below the screen is a 'SAND PACK' with 'TYPE OF SAND PACK'. The 'DIAMETER OF HOLE IN BEDROCK' and 'CORE / REAM' are noted. At the bottom, the 'ELEVATION / DEPTH BOTTOM SCREEN' and 'ELEVATION / DEPTH BOTTOM OF HOLE' are specified.

ELEVATION OF TOP OF SURFACE CASING: \_\_\_\_\_

STICK UP OF CASING ABOVE GROUND SURFACE: \_\_\_\_\_

ELEVATION TOP OF RISER: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF SURFACE CASING: \_\_\_\_\_

DIAMETER OF HOLE: \_\_\_\_\_

RISER PIPE I.D.: \_\_\_\_\_

TYPE OF RISER PIPE: \_\_\_\_\_

TYPE OF BACKFILL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SEAL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF BEDROCK: \_\_\_\_\_

TYPE OF SEAL: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SAND: \_\_\_\_\_

ELEVATION / DEPTH TOP OF SCREEN: \_\_\_\_\_

TYPE OF SCREEN: \_\_\_\_\_

SLOT SIZE x LENGTH: \_\_\_\_\_

I.D. SCREEN: \_\_\_\_\_

TYPE OF SAND PACK: \_\_\_\_\_

DIAMETER OF HOLE IN BEDROCK: \_\_\_\_\_

CORE / REAM: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM SCREEN: \_\_\_\_\_

ELEVATION / DEPTH BOTTOM OF HOLE: \_\_\_\_\_

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## 5.0 GUIDELINES

### 5.1 MEASUREMENT OF pH

#### 5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

#### 5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

#### 5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

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#### **5.1.4 Measurement Techniques for Field Determination of pH**

##### **1. pH Meter**

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

- a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.
- b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.
- c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
- d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- e. Immerse the electrode(s) in a pH-7 buffer solution.
- f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.
- g. Adjust the pH meter to read 7.0.
- h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.
- i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.
- k. Rinse the electrode(s) with deionized water.
- l. Keep the electrode(s) immersed in deionized water when not in use.



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The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

## 2. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

## 5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

### 5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

### 5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

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### 5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

### 5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

## 5.3 MEASUREMENT OF TEMPERATURE

### 5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

### 5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

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### 5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

## 5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

### 5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

### 5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

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easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

#### 5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

#### 5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

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## 5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

### 5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The technique therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

### 5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

### 5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

### 5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with demineralized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.
- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

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compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

## 5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

### 5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

### 5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

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### 5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

### 5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.
- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.
- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

## 6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

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## 7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.



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### ATTACHMENT A

#### SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES<sup>1</sup>

Temperature (°C)	Specific Conductance (µmhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

<sup>1</sup> Data derived from the International Critical  
Tables 1-3-8.

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### ATTACHMENT B

#### VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008

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**ATTACHMENT B**  
**VARIATION OF DISSOLVED OXYGEN CONCENTRATION**  
**IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY**  
**PAGE TWO**

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore used to correct measured D.O. concentration) using Attachment A.

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## 1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

## 2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

## 3.0 GLOSSARY

HCl - Hydrochloric Acid  
H<sub>2</sub>SO<sub>4</sub> - Sulfuric Acid  
HNO<sub>3</sub> - Nitric Acid  
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H<sub>2</sub>SO<sub>4</sub> containing two gram-atoms of H, is "two-normal."

## 4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

## 5.0 PROCEDURES

### 5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

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dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

## 5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO<sub>3</sub>, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

### 5.2.1 Addition of Acid (H<sub>2</sub>SO<sub>4</sub>, HCl, or HNO<sub>3</sub>) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

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Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H <sub>2</sub> SO <sub>4</sub>	1:1 dilution of concentrated H <sub>2</sub> SO <sub>4</sub>	18N	2-5 ml
HNO <sub>3</sub>	Undiluted concentrated HNO <sub>3</sub>	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

\* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

\*\* To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

#### 5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

#### 5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

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#### 5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

#### 5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

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## 6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. EPA-EMSL, Cincinnati, Ohio.

## 7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)



## SAMPLE PRESERVATION

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ATTACHMENT A  
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLESPT-7.06  
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	SAMPLE TYPE & CONCENTRATION	CONTAINER <sup>1</sup>	SAMPLE SIZE	PRESERVATION <sup>2</sup>	HOLDING TIME <sup>2</sup>
<u>WATER</u>					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	<u>Extractables</u>				
	Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	<u>Metals</u>				
	Low	high density (h.d.) polyethylene	1 l	HNO <sub>3</sub> to pH ≤2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	<u>Cyanide</u>				
	Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	14 days
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H <sub>2</sub> SO <sub>4</sub> to pH <2	20 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	20 days
Oil & Grease	--	glass	1.0 l	H <sub>2</sub> SO <sub>4</sub> to pH <2	20 days
Phenols	--	h.d. polyethylene	1.0 l	H <sub>2</sub> SO <sub>4</sub> to pH <2	20 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
<u>SOIL</u>					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	<u>Extractables</u>				
	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
<u>Air</u>					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

<u>Parameter No./Name</u>	<u>Container</u> <sup>(1)</sup>	<u>Preservation</u> <sup>(2,3)</sup>	<u>Maximum Holding Time</u> <sup>(4)</sup>
<b>INORGANIC TESTS:</b>			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid(5)	14 days(6)
Fluoride	P	None required	28 days
Hardness	P,G	HNO <sub>3</sub> to pH 2, H <sub>2</sub> SO <sub>4</sub> to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H <sub>2</sub> SO <sub>4</sub> to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
<b>METALS, (7)</b>			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO <sub>3</sub> to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO <sub>3</sub> to pH 2	6 months

**ATTACHMENT B**  
**REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES**

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Parameter No./Name	Container <sup>(1)</sup>	Preservation <sup>(2,3)</sup>	Maximum Holding Time <sup>(4)</sup>
<b>ORGANIC TESTS:<sup>(6)</sup></b>			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> HCl to pH 2 <sup>(8)</sup>	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> adjust pH to 4-5 <sup>(10)</sup>	14 days
Phenols <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction, 40 days after extraction <sup>(13)</sup>
Dechlorides <sup>(12)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction
Phthalate Esters <sup>(12)</sup>	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics <sup>(11,14)</sup>	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction, 40 days after extraction
PCBs <sup>(11)</sup> Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone <sup>(12)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> , store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup> , store in dark	7 days until extraction, 40 days after extraction
Halothanes <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDF <sup>(11)</sup>	G, Teflon-lined cap	Cool, 4°C, 0.008N Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> <sup>(5)</sup>	7 days until extraction, 40 days after extraction
<b>PESTICIDES TESTS:</b>			
Pesticides <sup>(12)</sup>	G, Teflon-lined cap	Cool, 4°C, pH 3-9 <sup>(15)</sup>	7 days until extraction, 40 days after extraction
<b>RADIOLOGICAL TESTS:</b>			
1-5 Alpha, beta and radium	P, G	WHO <sub>2</sub> to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the type of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

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REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

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(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.0001 sodium thiosulfate, storing in the dark, and adjusting the pH to 8-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benazidins).

(12) If 1,3-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benazidins.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxygen-free) atmosphere.

(14) For the analysis of diphenylnitrobenzines add 0.0001 Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.0001 Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.

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## **1.0 PURPOSE**

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

## **2.0 SCOPE**

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

## **3.0 GLOSSARY**

None.

## **4.0 RESPONSIBILITIES**

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

## **5.0 PROCEDURES**

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

### **5.1 ACCESS FOR SAMPLING**

#### **5.1.1 Bailers and Bailing Line**

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

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Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point is heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution\*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse\*\*
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

#### 5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid fractions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

\* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

\*\* If sampling for pesticides, PCBs, or fuels.

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### **5.1.3 Filtering Equipment**

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

## **5.2 FIELD ANALYTICAL EQUIPMENT**

### **5.2.1 Water Level Indicators**

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

### **5.2.2 Probes**

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

## **6.0 REFERENCES**

None.

## **7.0 RECORDS**

None.



Designation: D 1586 - 84

## Standard Method for Penetration Test and Split-Barrel Sampling of Soils<sup>1</sup>

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

### 1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For a specific precautionary statement, see 5.4.1.*

1.3 The values stated in inch-pound units are to be regarded as the standard.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 2487 Test Method for Classification of Soils for Engineering Purposes<sup>2</sup>
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>2</sup>
- D 4220 Practices for Preserving and Transporting Soil Samples<sup>2</sup>

### 3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the  $140 \pm 2$  lb ( $63.5 \pm 1$  kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N-value*, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9  $\Delta N$ —the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by  $360^\circ$  (see Fig. 1).

3.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

### 4. Significance and Use

4.1 This method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N-value*, and the engineering behavior of earthworks and foundations are available.

### 5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in

<sup>1</sup> This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.



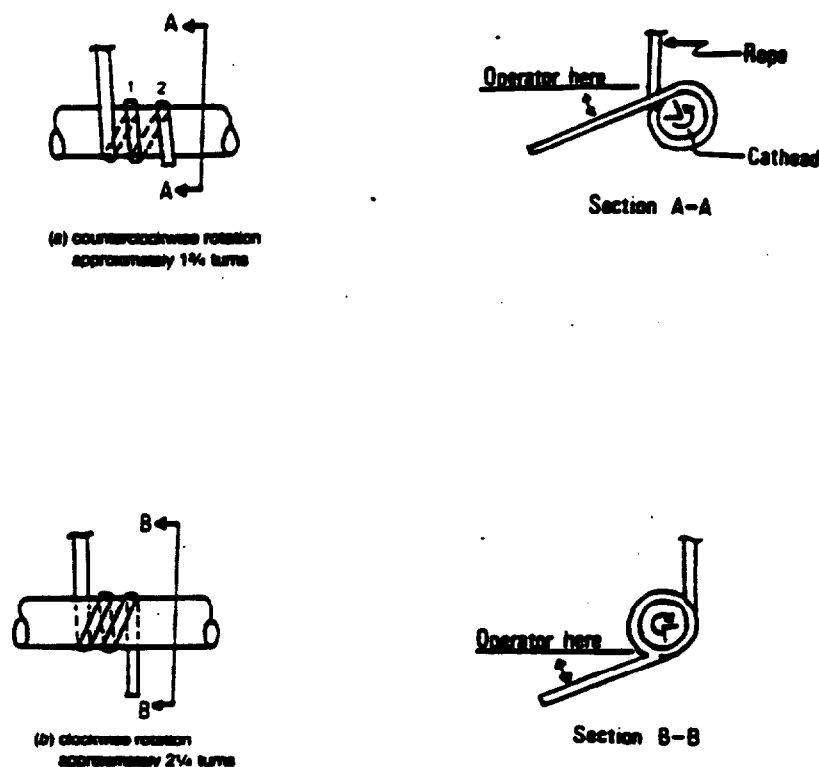


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1 1/2 in. (41.2 mm) and an inside diameter of 1 1/8 in. (28.5 mm)).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1 1/2 in. (35 mm) is permitted, but shall be noted on the penetration

record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

#### 5.4 Drive-Weight Assembly:

5.4.1 *Hammer and Anvil*—The hammer shall weigh  $140 \pm 2$  lb ( $63.5 \pm 1$  kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

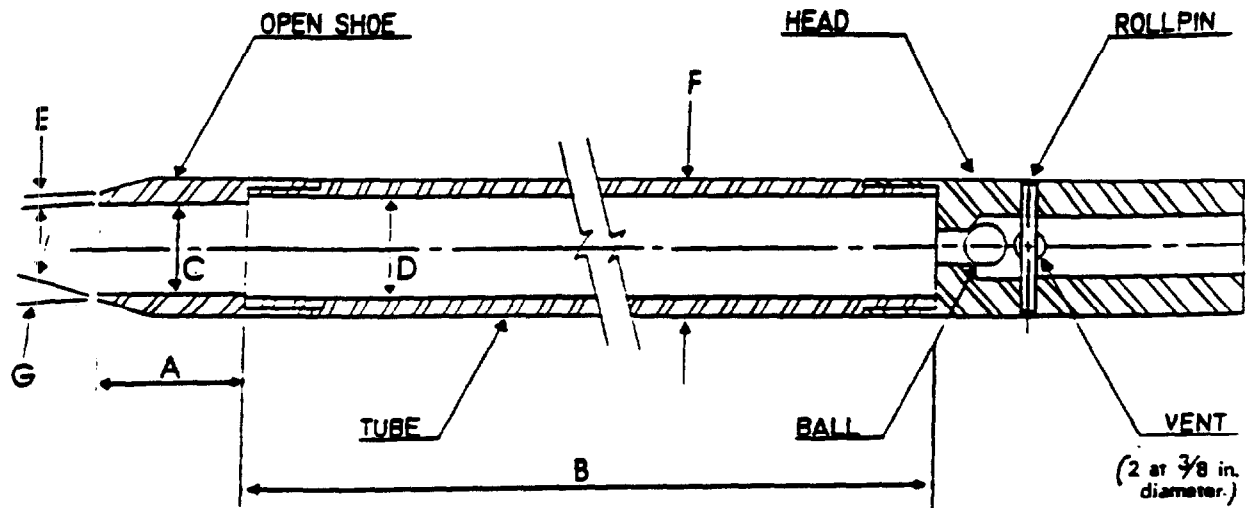
NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

## 6. Drilling Procedure

6.1 The boring shall be advanced incrementally to pc



- A = 1.0 to 2.0 in. (25 to 50 mm)
- B = 18.0 to 30.0 in. (0.457 to 0.762 m)
- C =  $1.375 \pm 0.005$  in. ( $34.93 \pm 0.13$  mm)
- D =  $1.50 \pm 0.05 - 0.00$  in. ( $38.1 \pm 1.3 - 0.0$  mm)
- E =  $0.10 \pm 0.02$  in. ( $2.54 \pm 0.25$  mm)
- F =  $2.00 \pm 0.05 - 0.00$  in. ( $50.8 \pm 1.3 - 0.0$  mm)
- G =  $18.0^\circ$  to  $23.0^\circ$

The  $1\frac{1}{2}$  in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ

groundwater level at all times during drilling, removal of drill rods, and sampling.

## 7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

- 7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.
- 7.2.2 A total of 100 blows have been applied.
- 7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "N-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop  $30 \pm 1.0$  in. (0.76 m  $\pm$  25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than  $2\frac{1}{4}$  rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

**NOTE 4—**The operator should generally use either  $1\frac{1}{4}$  or  $2\frac{1}{4}$  rope turns, depending upon whether or not the rope comes off the top ( $1\frac{1}{4}$  turns) or the bottom ( $2\frac{1}{4}$  turns) of the cathead. It is generally known and accepted that  $2\frac{1}{4}$  or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unraveled condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job

designation, boring number, sample depth, and blow count per 6-in. (0.15-m) increment. Protect the sample against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note location in the sampler barrel.

## 8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

- 8.1.1 Name and location of job.
  - 8.1.2 Names of crew.
  - 8.1.3 Type and make of drilling machine.
  - 8.1.4 Weather conditions.
  - 8.1.5 Date and time of start and finish of boring.
  - 8.1.6 Boring number and location (station and coordinates, if available and applicable).
  - 8.1.7 Surface elevation, if available.
  - 8.1.8 Method of advancing and cleaning the boring.
  - 8.1.9 Method of keeping boring open.
  - 8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made.
  - 8.1.11 Location of strata changes.
  - 8.1.12 Size of casing, depth of cased portion of boring.
  - 8.1.13 Equipment and method of driving sampler.
  - 8.1.14 Type sampler and length and inside diameter of barrel (note use of liners).
  - 8.1.15 Size, type, and section length of the sampling rods, and
  - 8.1.16 Remarks.
- 8.2 Data obtained for each sample shall be recorded in the field and shall include the following:
- 8.2.1 Sample depth and, if utilized, the sample number.
  - 8.2.2 Description of soil.
  - 8.2.3 Strata changes within sample.
  - 8.2.4 Sampler penetration and recovery lengths, and
  - 8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

## 9. Precision and Bias

9.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.3 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is currently under development.

**D 1586**

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*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.*

**APPENDIX B**

**FIELD INVESTIGATION FORMS**  
**NSB-NLON, SUBASE-NEW LONDON**  
**GROTON, CONNECTICUT**



☐ Monitoring Well Data  
☐ Domestic Well Data  
☐ Other \_\_\_\_\_

By \_\_\_\_\_

[illegible]

# SAMPLE LOG SHEET

Page        of       

Case # \_\_\_\_\_

By \_\_\_\_\_

- ☐ Surface Soil  
☐ Subsurface Soil  
☐ Sediment  
☐ Lagoon / Pond  
☐ Other \_\_\_\_\_

Project Site Name \_\_\_\_\_ Project Site Number \_\_\_\_\_

NUS Source No. \_\_\_\_\_ Source Location \_\_\_\_\_

Sample Method:		Composite Sample Data	
		Sample	Time      Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			
<b>Type of Sample</b> <input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab - Composite			
		<b>Sample Data</b>	
		Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)
Analysis:	PRESERV.	Observations / Notes	
			Organic      Inorganic
		Traffic Report #	
		Tag #	
		AB #	
		Date Shipped	
		Time Shipped	
		Lab	
		Volume	

# Halliburton NUS

BORING NO

DATE:

DRILLER:

FIELD GEOLOGIST

**(Date, Time & Conditions)**

[illegible]

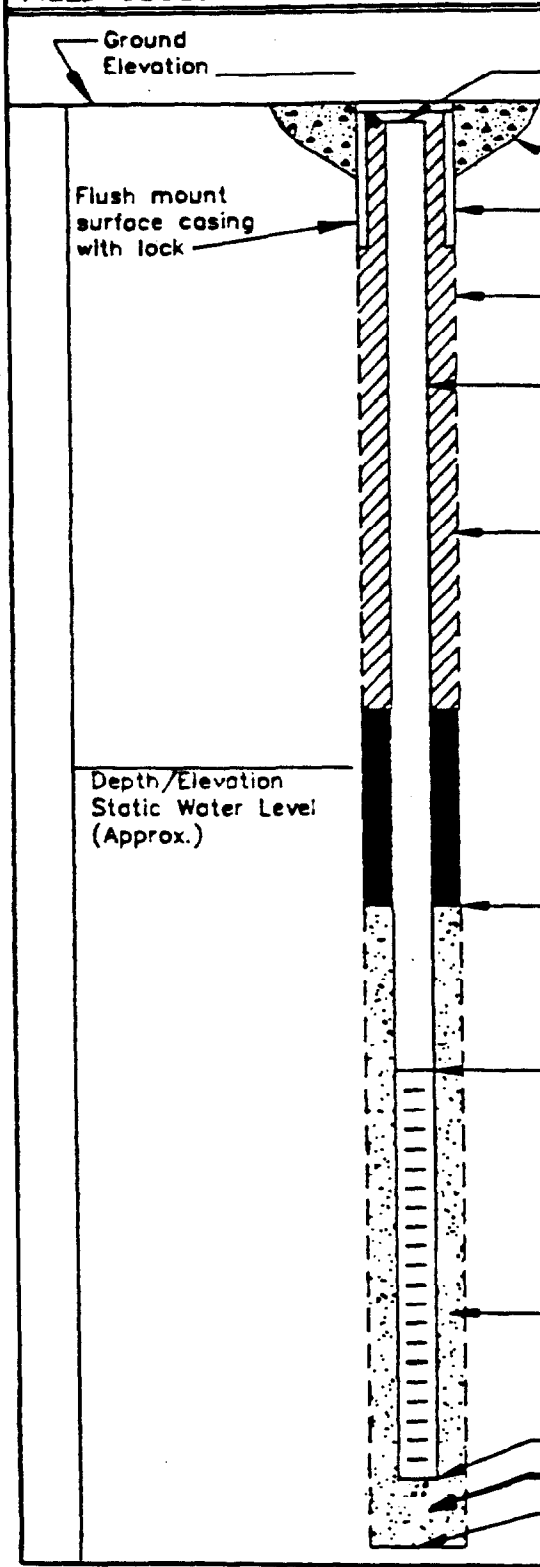
**BORING**

**PAGE**



# OVERBURDEN MONITORING WELL SHEET

PROJECT: _____	LOCATION: _____	DRILLER: _____
PROJECT NO.: _____	BORING: _____	DRILLING METHOD: _____
ELEVATION: _____	DATE: _____	DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____		

	ELEVATION TOP OF RISER: _____ TYPE OF SURFACE SEAL: _____ TYPE OF PROTECTIVE CASING: _____ I.D. OF PROTECTIVE CASING: _____ BOREHOLE DIAMETER: _____ TYPE OF RISER PIPE: _____ RISER PIPE I.D.: _____ TYPE OF BACKFILL/SEAL: _____ _____ DEPTH/ELEVATION TOP OF SAND: _____ / _____ DEPTH/ELEVATION TOP OF SCREEN: _____ / _____ TYPE OF SCREEN: _____ SLOT SIZE x LENGTH: _____ TYPE OF SAND PACK: _____ DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____ DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____ DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____ BACKFILL MATERIAL BELOW SAND: _____
	Ground Elevation _____ Flush mount surface casing with lock _____ Depth/Elevation Static Water Level (Approx.) _____

# HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

HALLIBURTON NUS CORPORATION

PROJECT NAME: ..... WELL/BORING NO.: .....  
 PROJECT NO.: ..... GEOLOGIST: .....  
 WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....  
 STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....  
 TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....  
 METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE OF  
 REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	WELL SCHEMATIC
						WELL
						BOREHOLE
						Depth (BGL)
						SEAL
						CRUEL / OPEN INTERVAL
						SCREEN
						Indicate SWL Depth on Drawing

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REMARKS:  
 .....  
 .....  
 .....

CALCS. SKETCH MAPS, ETC..  
 .....  
 .....  
 .....

## Halliburton NUS

[illegible]**DRILLER OR REPRESENTATIVE**



**HALLIBURTON NUS**  
*Environmental Corporation*

## EQUIPMENT CALIBRATION LOG

**Instrument (Name/Model No./Serial No.): \_\_\_\_\_**

**Manufacturer** \_\_\_\_\_ **Date Purchased** \_\_\_\_\_

[illegible]

**NUS CORPORATION**

Project Name: \_\_\_\_\_ Location: \_\_\_\_\_  
Project No.: \_\_\_\_\_ Weather Conditions: \_\_\_\_\_  
Personnel: \_\_\_\_\_ Measuring Device: \_\_\_\_\_  
Date: \_\_\_\_\_ Remarks: \_\_\_\_\_  
Tidally Influenced: Yes \_\_\_\_\_ No \_\_\_\_\_

[illegible]

PROJECT NO.:					SITE NAME:					NO. OF CON- TAINERS							REMARKS
SAMPLERS (SIGNATURE):																	
STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION												
RELINQUISHED BY (SIGNATURE):			DATE/TIME:		RECEIVED BY (SIGNATURE):					RELINQUISHED BY (SIGNATURE):			DATE/TIME:		RECEIVED BY (SIGNATURE):		
RELINQUISHED BY (SIGNATURE):			DATE/TIME:		RECEIVED BY (SIGNATURE):					RELINQUISHED BY (SIGNATURE):			DATE/TIME:		RECEIVED BY (SIGNATURE):		
RELINQUISHED BY (SIGNATURE):			DATE/TIME:		RECEIVED FOR LABORATORY BY (SIGNATURE):					DATE/TIME:		REMARKS:					